Activating Circular Services in the Electric and Electronic Sector

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Deliverable 5.4.
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Social life cycle assessment (S-LCA)

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Executive summary

The C-SERVEES project aims to boost a resource-efficient circular economy in the electrical and electronic sector through the development, validation and transfer of new circular economy business models. These models are based on systemic eco-innovative services that include: (1) eco-leasing of EEE, (2) product customization, (3) improved WEEE management, and (4) ICT services to support other eco-services.

The new circular economic business models were implemented and tested by means of demonstrations involving four target products: washing machines, laser printers and their toner cartridges, telecom equipment and TV sets. The demonstrations involve the whole life cycle of the four target products, their associated value and supply chains, and the proposed eco-innovative services.

The techno-economic, environmental and social feasibility of the target products and related eco-services were determined by means of life cycle sustainability assessment tools (LCSA), including environmental life cycle assessment (LCA), life cycle costing (LCC) and social life cycle assessment (S-LCA). Two different types of scenario were assessed and compared for each target product:

- A conventional scenario, in which the products are produced and consumed under linear economy models.
- The C-SERVEES scenario, in which the products are produced and consumed under the new circular economy models relying on the systemic eco-innovative services demonstrated in the project.

This Deliverable 5.4 shows the social life cycle assessment of each target product under the conventional scenario, called Reference product, and under the C-SERVEES scenario, called C-SERVEES product, and their comparison.

The social impacts for the four target products were calculated using the S-LCA methodology. In particular, the method and the indicators of the Social Hotspot Database were used. It allows to calculate social impacts. A cradle-to-gate assessment was applied, meaning that the scope of the social assessment covered from the extraction and processing of raw materials to the delivery of the finished product at the factory gate, acts for 26 social subcategories grouped into 5 categories. The SHDB offers a weighted model that converts the impact values of the social subcategories into aggregate impact values for each social category, which in turn can be aggregated into a single global social footprint for the products (the so-called Social Hotspot Index or SHI).

Below are shown the main social indicators calculated for the four target products with their two scenarios and the relative reduction of the social impacts, referred to their functional unit, including:

1) One washing cycle with an **ARÇELIK 7150370100 washing machine as Reference product and ARÇELIK 7150341600 as C-SERVEES product.**

Main social life cycle indicators for one washing cycle of the washing machine.

Washing machine	Indicator	Unit	Reference	C-SERVEES	Relative reduction
	Labour Rights & Decent Work	Pt	0.24	0.24	0.0%
	Health & Safety	Pt	0.29	0.29	0.0%
	Human Rights	Pt	0.17	0.17	0.0%
	Governance	Pt	0.38	0.38	0.0%
	Community	Pt	0.14	0.14	0.0%
	Total – Social Hotspot Index	Pt	1.22	1.22	0.0%

2) 1,000 printed pages with a **LEXMARK CX860dte professional multifunctional laser printer**

Main social life cycle indicators for 1000 printed pages of the multifunctional laser printer.

Multifunctional laser printer	Indicator	Unit	Reference	C-SERVEES	Relative reduction
	Labour Rights & Decent Work	Pt	35.12	34.56	1.6%
	Health & Safety	Pt	49.54	49.10	0.9%
	Human Rights	Pt	25.43	24.89	2.1%
	Governance	Pt	61.48	61.86	-0.6%
	Community	Pt	20.65	20.24	2.0%
	Total – Social Hotspot Index	Pt	192.21	190.65	0.8%

3) One hour of the **telecommunications equipment** monitoring composed by **an active ALM unit (ADVA 16ALM/#1650D/AC) and 50 passive sensors**

Main social life cycle indicators for one hour of the ALM product monitoring.

ALM product	Indicator	Unit	Reference	C-SERVEES	Relative reduction
	Labour Rights & Decent Work	Pt	0.14	0.07	46.9%
	Health & Safety	Pt	0.23	0.12	46.9%
	Human Rights	Pt	0.11	0.06	46.9%
	Governance	Pt	0.19	0.10	46.9%
	Community	Pt	0.07	0.04	46.9%
	Total – Social Hotspot Index	Pt	0.74	0.40	46.9%

4) One watched hour of the **GRUNDIG G43C 891 5A 43" smart-TV set**

Main social life cycle indicators for one watched hour of the TV set.

TV set	Indicator	Unit	Reference	C-SERVEES	Relative reduction
	Labour Rights & Decent Work	Pt	0.12	0.10	13.9%
	Health & Safety	Pt	0.15	0.12	20.1%
	Human Rights	Pt	0.08	0.07	9.2%
	Governance	Pt	0.19	0.17	12.0%
	Community	Pt	0.06	0.06	6.8%
	Total – Social Hotspot Index	Pt	0.60	0.52	13.5%

It should be noted that these results cannot be used to compare the products with each other, since each product has its own functions and functional unit, intensity of use, number of users per product unit and lifetime, resulting in products completely different in terms of composition, weight, life-cycle management and derived impacts; e.g., the washing machine is a consumer product used at home by a family, while the professional multifunctional laser printer is a large business product used by several office workers (over 30 users per product unit).

The main conclusion of this Deliverable 5.4 is that the four target products under the new circular economy models relying on the systemic eco-innovative services, demonstrated in the project, have reduced social impacts by an average of 15%.

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List of acronyms and abbreviations

Acronym	Full form
3D	Three dimensions
ABS	Acrylonitrile Butadiene Styrene
ALM	Advanced link monitoring
B2B	Business-to-business
B2C	Business-to-customer
CD	Compact disc
CE	Conformité Européenne
CSS	Country-Specific Sector
EEE	Electric and electronic equipment
EI	Environmental impacts
EoL	End-of-life
E2N	Equal to new
FU	Functional Unit
GB	Gigabyte
GTAP	Global trade analysis project
HEVC	High efficiency video coding
Hz	Herzio
ICT	Information and communication technologies
L	Lifetime
LCA	Life cycle assessment
LCC	Life cycle cost
LCCP	Lexmark cartridge collection program
LCI	Life cycle inventory
LCIA	Life cycle impact assessment
LCSA	Life cycle sustainability assessment
LED	light-emitting diode
LECP	Lexmark Equipment and Collection Program
MLP	Multifunction laser printer
Mrheq	Medium risk hours equivalent
PET	Polyethylene terephthalate
PSS	Product service systems
QR	Quick response code
RC	Recycled content
rPC	Recycled paper and cardboard
SHDB	Social hotspot database
SHI	Social hotspot index
S-LCA	Social life cycle assessment
TE	Telecom equipment
TR	Percentage of time replaced
TV	Television
U	Functional unit
USD	United States dollar
VAT	Value added tax
WEEE	Waste of electric and electronic equipment
Wi- Fi	Wireless Fidelity
WM	Washing machine
WP	Work package

1 Introduction

C-SERVEES is a European H2020 project that aims to boost a resource-efficient circular economy in the electrical and electronic sector through the development, testing, validation and transfer of new circular economic business models. The new circular business models, developed in WP2, are based on systemic eco-innovative services that include: (1) eco-leasing of EEE, (2) product customization, (3) improved WEEE management, and (4) ICT services to support the other eco-services. ICT tools were developed in WP3 as a driver of the proposed eco-innovative services. Figure 1 shows a schematic overview of the C-SERVEES project and its main innovative solutions.

The new circular economic business models were implemented and tested in WP4 by means of demonstrations involving four target products: washing machines, multifunctional laser printers and their toner cartridges, telecom equipment and TV sets. These products belong to different EEE categories that jointly account for 77% of the WEEE collected in the EU. The demonstrations involve the whole life cycle of the four target products, their associated value and supply chains, and the proposed eco-innovative services.

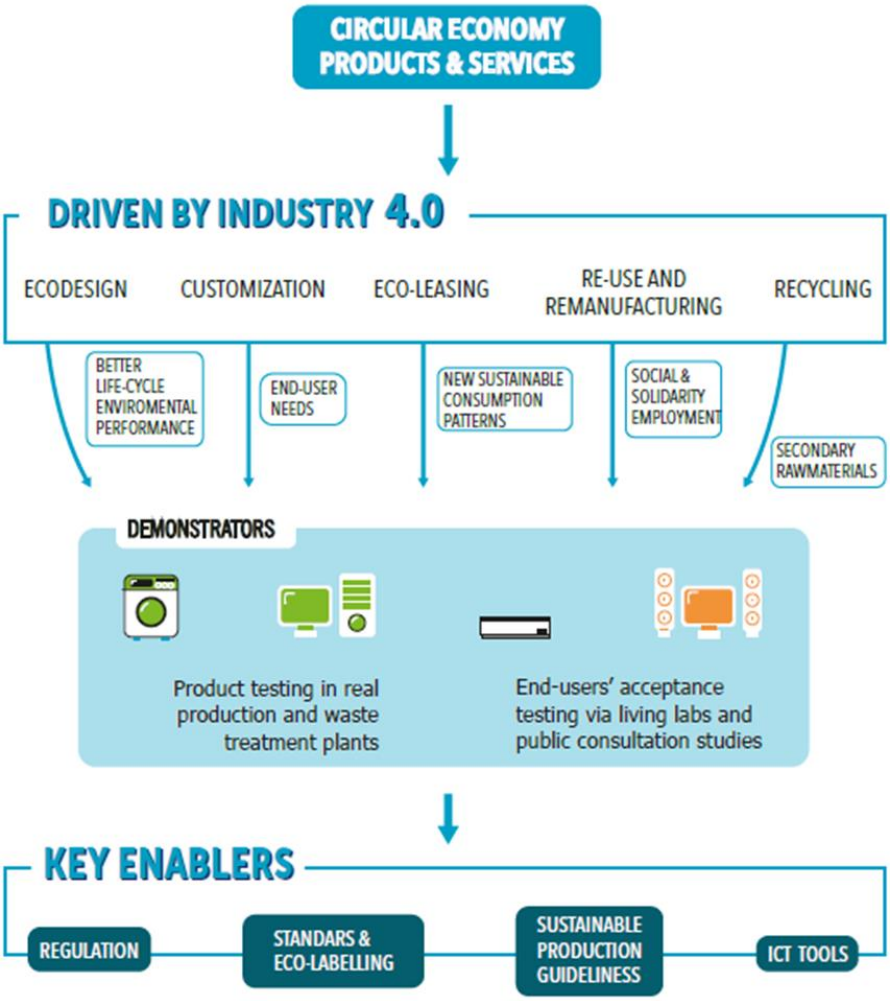

Figure 1. Schematic overview of the C-SERVEES project.

The environmental, economic and social viability of the target products and related eco-services were determined in WP5 by means of life cycle sustainability assessment tools, including: environmental life cycle assessment (LCA), life cycle costing (LCC) and social life cycle assessment (S-LCA). Two different types of scenarios were assessed and compared for each target product:

- A conventional scenario, in which the products are produced and consumed under linear economy models.
- The C-SERVEES scenario, in which the products are produced and consumed under the new circular economy models relying on the systemic eco-innovative services demonstrated in the project.

This Deliverable 5.4 shows the social life cycle assessment of each target product under the conventional scenario, called Reference product, and under the C-SERVEES scenario, called C-SERVEES product, and their comparison.

1.1 Context and relationship with other WPs

C-SERVEES project is structured into 9 work packages (WPs). Figure 2 shows the overall structure of the project work plan as well as the interlinkages between the different WPs.

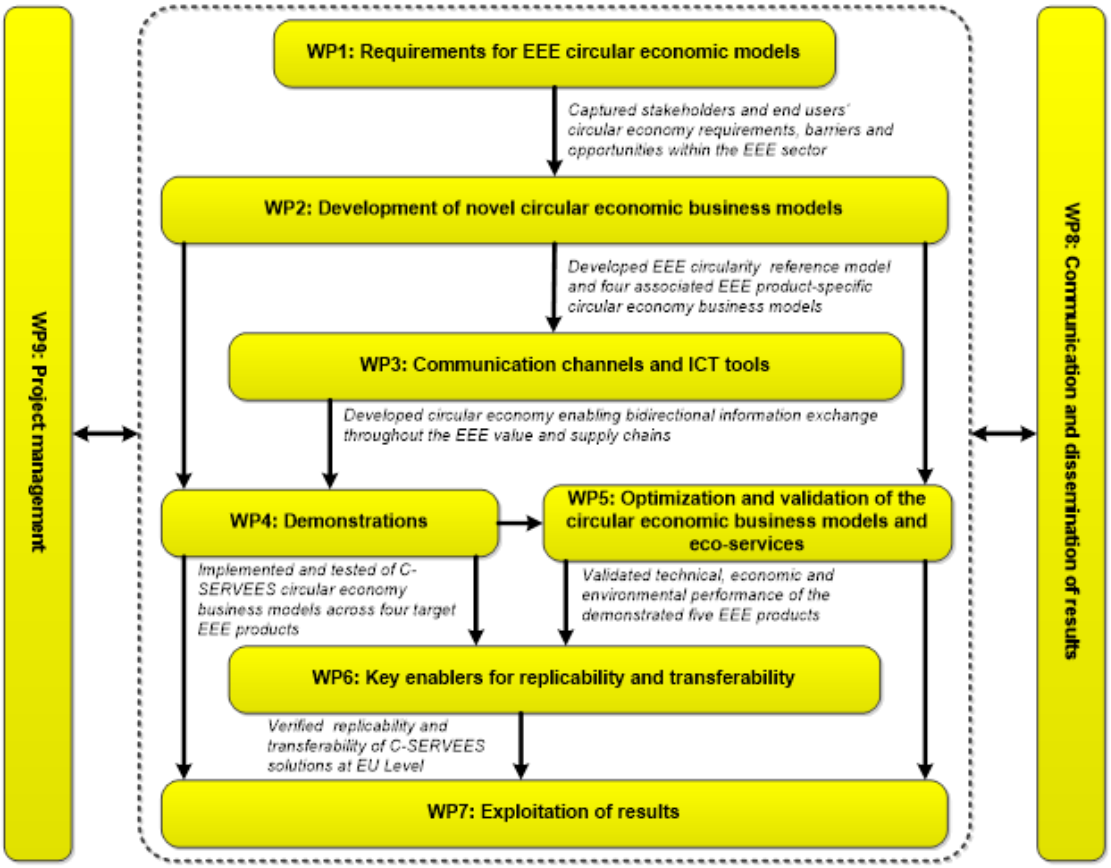

Figure 2. WP structure of the C-SERVEES project.

This Deliverable 5.4 is part of WP5, whose main objective is to validate the new circular business models by verifying their social feasibility. The relationship of WP5 (and Deliverable 5.4 in particular) with the other previous WPs is explained below.

WP1. Requirements for the new circular economic models

Stakeholder consultation was initially conducted to identify the awareness, opportunities, challenges and enablers to implement the circular economy business models in the electrical and electronic sector. These comprised technical, business & management, legislative, economic, social, supply chain and implementation aspects (discussed in Deliverable 1.2).

WP2. Definition of new circular economic business models

A circular business reference model for the electrical and electronic sector (REF-CIRCMODE) was developed based on a comprehensive literature review, the findings of the stakeholder consultation (conducted in WP1) and requirements from industry partners in the EEE value chains. The reference model comprises five interlinked layers (presented in Deliverable 2.1): (1) Business Strategy, (2) Circular Economic Business Model Canvas, (3) Challenges and Opportunities, (4) EU Policies relevant to the electrical & electronic sector, and (5) Circularity Indicators.

The REF-CIRCMODE was designed to be relevant to all EEE products and its layered structure provides a framework encompassing all possible circular economy options at a strategic level as well as each stage of a product's life cycle (design, production, use and EoL). This ensures that all options are initially available when implementing the REF-CIRCMODE to meet the requirements of any specific EEE product, providing the most appropriate actions that leaded to the optimum product-specific circular economic business model.

The REF-CIRCMODE was further customised and tailored to the four specific products targeted in the project, resulting in four oriented product-specific circularity models:

- WASH-CIRCMODE for washing machines produced by ARÇELIK (presented in Deliverable 2.2).
- PRINT-CIRCMODE for printer products produced by LEXMARK, including laser printers and toner cartridges (presented in Deliverable 2.3).
- ALM-CIRCMODE for telecom equipment produced by ADVA (presented in Deliverable 2.4).
- TV-CIRCMODE for TV sets and displays produced by ARÇELIK (presented in Deliverable 2.5).

The four product-specific circular economic business models are therefore equally based on the characteristics of the REF-CIRCMODE. Each business model, however, relates to the specificities of the specific product, since each one was developed using the information provided by the corresponding producer and other actors in its associated value chain.

WP3. Communication channels and ICT tools

C-SERVEES is also dealing with the development of ICT tools for bi-directional communication and secure information exchange throughout the EEE value chains to support the new circular economic business models. These tools are based on blockchain and zero-knowledge technology, enabling the communication about individual products without the need for full disclosure of information, but with trust and accountability.

New ICT services were thus be provided and supported by information transfer through the EEE value chains, including EEE producers and their supply chains, end users and WEEE managers. These services were relied on QR codes (requiring product labelling), providing access to end users via their smartphones, while WEEE managers can use QR code scanners. Functionalities included product life-cycle tracking and feedback to producers, as well as interactive user manuals, repair manuals, warranty tracking or consumables management.

The ICT tools were developed in sprints with industry partners that tested them to validate and optimise their features and functionalities. They were structured in such a way that any type of EEE can be added to the ICT platform.

WP4. Demonstrations of the circular economic business models and eco-services

The practical utility of the product-specific circular economic business models (developed in WP2) lies in the possibility of posing and reviewing a series of circular economy options and evaluating them according to their viability and timeframes for implementation (short, medium or long term). This exercise was carried out by each EEE producer in C-SERVEES (ARÇELIK, LEXMARK and ADVA), leading to the selection of a set of circular economy actions that can be reasonably applied to their demo products within the timescale of the project (i.e., in the short term).

The actions initially selected for each target product (as for the WP2 and related deliverables D2.2, D2.3, D2.4 and D2.5) were implemented through the demonstrations for the 'Design and Production' phase (presented in Deliverable 4.1). These potential actions for increasing circularity from WP2 are summarized in Table 1, including some actions supported by the ICT tools developed in the project (in WP3). In addition, other circular economy actions considered feasible over a longer timescale (i.e., medium and long term) were explored by EEE producers for possible progression outside the confines of the project.

Table 1. Demonstration circular economy actions to be conducted along the C-SERVEES project for Washing Machines.

Demo product (producer)	Life-cycle stage	Circular economy action	Action description
Washing machines (ARÇELIK) 	Design & production	Eco-design of the washing machine	• Increase recycled plastic content in washing machines' components • Use novel formula to increase recycled PET content in the washing machines' tub to make it more durable • Use QR codes to provide information about materials and company's circularity to all the value chain
		Increase circularity in production process	• Perform LCA to detect improvement areas in production
	Use	Develop a renting model for B2B market	• Demonstration with focus on corporate customers • Obtain feedback from washing machines' B2B customers via questionnaires • Develop new corporate B2B sales channels in Europe for renting washing machines • Develop a washing machine rental business model • Assess the feasibility of washing machines' leasing/renting options • Target low income customers for the sale or rent of refurbished washing machines' (students, pensioners, house shares, etc.)
	End of life	Expand and improve repair & refurbishment operations	• Collect end of life products from B2B customers, refurbish them and provide refurbished products to B2B customers as a new business line • Enable collection of end-of use-washing machines' back from customers with a partner in Europe • Explore the use of 3D printing for spare parts and/or customisation • Reuse motors and electrical cards from returned washing machines as spare parts in Turkey • Develop dismantling and repair training programmes • Create awareness in relation to washing machines' circularity among B2B consumers via the help of QR codes inserted in products, which include examples of Arçelik's best practices in terms of circularity • Expand partnerships with Arçelik dealers and retailers to sell remanufactured B2C washing machines'
		Improve recycling process/recovering of the washing machine	• Use a QR code on washing machines' components to track their service call rate • Initiate a take back collection system for end of use washing machines in Europe with a partner • Develop circular end-of-life recovery strategies for collected washing machines outside Turkey

Table 2. Demonstration circular economy actions to be conducted along the C-SERVEES project for Laser Printers.

Demo product (producer)	Life-cycle stage	Circular economy action	Action description
Printer products, incl. laser printers and toner cartridges (LEXMARK) 	Design & production	Eco-design of the printer	• Identify levers to reduce dismantling and refurbishing cost by setting various operating models • Provide information about printers to LEXMARK recycling partners • Use materials that recyclers can easily and profitably recycle • Use ICT to support information sharing across the supply chain related to recycled content • Devise an eco-design strategy for printers during dismantling activities
		Increase circularity in the printer's life cycle	• Expand LCCP and/merge with LECP program (collecting and refurbishing whole printers and key components) • Assess options to reuse material from EoL/WEEE printers • Learn from recyclers what materials can be recycled better or more profitably to use more of them instead of low-recycle value or efficiency materials
	Use	Improve data collection and management	• Reduce the number of unnecessary and incorrect shipments • Salvage working and repairable parts from collected/return printers and use on E2N (Equal to New) printers • Increase the flow of returned end-of-life printers by reducing the associated time and cost • Explore the competitiveness of 3D printing for spare plastic parts • Engage with key customer to understand their needs and requirements as it relates to refurbished products • Active lobbying at EU and/or national level for wider acceptance and promotion of circular business models • Active media campaign on refurbished printers • Promote refurbished printers • Use QR code to inform customers about options to return their unused products to the manufacturer • Investigate economics of more CE suitable materials coming from end-of-life cartridges or printers
	End of life	Improve the LCCP	• Expand LCCP and/merge with LECP program (collecting and refurbishing whole printers and key components) • Implement ICT tools for improvement in logistics
		Improve the recycling of printers and cartridges	• Maintain highest levels of data security by ensuring that customers' documents are erased from refurbished (E2N) printers

Table 3. Demonstration circular economy actions to be conducted along the C-SERVEES project for ALM product.

Demo product (producer)	Life-cycle stage	Circular economy action	Action description
Telecom equipment (ADVA) 	Design & production	Eco-design of ALM system	• Design for longevity, in particular better maintainability • Design for better recycling, related to plastics • Improve energy efficiency in the use phase by at least 20% • Devise an eco-design approach in production and Design for Recycling • Reduce costs of manual disassembly for recycling
		Improve circularity in ALM production	• Perform LCA to detect improvement areas in production
	Use	Improvements in performance	• Implement eco-design strategies across the life cycle of ALM products and the subsequent reduction of energy use
		Explore feasibility of renting/shared use/PSS	• In-depth PSS analysis considering lifetime and other ICT product • Introduce options for leasing, renting or sharing products • Expand the scope of PSS (moving toward vendor ownership) • Move towards a rental model for B2B customers • Demonstration of leasing/renting with selected stakeholder
	End of life	Improve repair and refurbishment operations	• Carry out a feasibility analysis of AI for predictive maintenance • Assess components' reuse • Provide an analysis of part-exchange options as part of repair and maintenance
		Improve recycling of the ALM system	• Assign components to most efficient recycling pathways • Provide an analysis of how recycling needs to be changed to become more efficient • Define which level of material data is suitable for recyclers • Improve the proportion of components, parts and/or materials recovered • Reduce volume of packaging and develop plastic-free packaging

Table 4. Demonstration circular economy actions to be conducted along the C-SERVEES project for ALM product.

Demo product (producer)	Life-cycle stage	Circular economy action	Action description
TV sets (ARÇELIK) 	Design & production	Eco-design of the TV set	• Increase recycled plastic content in TV components • Increase the durability of LED panel and mainboard • Use QR codes to provide information about materials and company's circularity to all the value chain
		Increase circularity in production process	• Perform LCA to detect improvement areas in production
	Use	Develop a renting model for B2B market	• Demonstration with focus on corporate customers • Use 3D printing for TV components • Obtain feedback from TV B2B customers via questionnaires and living labs • Develop new corporate B2B sales channels in Europe for renting TVs • Develop a TV rent business model for Smart Boards and Digital Signage products • Assess the feasibility of TV renting options
	End of life	Expand and improve repair and refurbishment operations	• Collecting and remanufacturing end of use TV sets • Enable traceability of remanufactured TV parts • Develop dismantling and repair training programmes • Create awareness among TV B2B consumers via the help of QR codes inserted in products • Expand partnerships with ARÇELIK TV dealers and retailers to sell remanufactured B2C TVs • Target low-income customers for the sale or rent of refurbished TVs (students, pensioners, house shares, etc.) • Initiate a take back collection system in Europe with a partner
		Improve recycling process of the TV set	• Decrease packaging waste • Increase circularity of TV waste plastics • Develop circular end-of-life recovery strategies for end of use TVs outside Turkey

WP5. Optimization and validation of the circular economic business models and eco-services

The main objective of this WP was to validate the new circular economic business models by verifying their sustainability in the demonstrations of the four EEE products. The evaluation of the proposed solutions was conducted by applying life cycle sustainability assessment tools (LCSA) over the demonstrations to measure their performance in relation to the three pillars of sustainability (Figure 3):

- Environmental viability, measured with life cycle assessment (LCA, performed in Task 5.1).
- Economic viability, measured with life cycle costing (LCC, performed in Task 5.2).
- Social viability, measured with social life cycle assessment (S-LCA, performed in Task 5.3).

Figure 3. Life cycle sustainability assessment approach applied in the C-SERVEES project.

Two different types of scenarios were assessed and compared for each target product to validate the sustainability of the new circular business models:

- A conventional scenario, in which the products are produced and consumed under linear economy models.
- The C-SERVEES scenario, in which the products are produced and consumed under the new circular economy models relying on the eco-innovative services demonstrated in the project (in WP4).

A preliminary LCSA was included in D5.1. However, during the development of the C-SERVEES project and in accordance with the definition of the circular models, some changes were introduced in some parts of the linear product to achieve a more representative comparison.

This Deliverable 5.4 shows the social life cycle assessment of each target product under the conventional scenario, called Reference product, and under the C-SERVEES scenario, called C-SERVEES product. The impacts of the C-SERVEES scenario are also compared to those for the conventional scenario, also compiled here and replacing Deliverable 5.1, to calculate the sustainability benefits that can be achieved with the solutions developed in the project.

1.2 Structure of the Deliverable

Deliverable 5.4 contains the following sections:

- Introduction to C-SERVEES project with the overview of WP5 and its relationship with previous WPs.
- Definition of the Goal and Scope of the Deliverable.
- Methodology of the social life cycle assessment (S-LCA).

- One chapter for each target product containing the full S-LCA of the reference product, the C-SERVEES product and the comparative assessment.
- Conclusions.

2 Goal and scope

The present study aimed to calculate the environmental, economic and social impacts of four different EEE products used for demonstrations in the C-SERVEES project. The target products investigated include:

- Washing machine
- Multifunctional laser printer (including its toner cartridges)
- Telecom equipment
- TV set

The sustainability analysis is performed on the Telecommunication equipment (TE) which central device is called Advanced link monitoring (ALM).

These products and their main characteristics are described below.

Different Product Category Rules[1] aimed for stablishing different Environmental Product Declarations for similar EEE products showed that the functional unit is defined by two approaches:

1. A unit of the product, or/and
2. Dedicated function of the product

The first approach was justified in the way that each product is “marketed and sold in such units”. This is intended to cover the end-user acceptance. On the other hand, comparison among the different products seems not straightforward when functionalities change. For that reason, each product was evaluated also against the functional unit defined for them.

This means that the assessment of each product was conducted for a unit of the product/system. Results are presented then both as per unit of the product but also as per the functional unit the product is intended for.

The social impacts for the four target products were calculated using the S-LCA methodology. In particular, the method and the indicators of the Social Hotspot Database were used. It allows to calculate social imp A cradle-to-gate assessment was applied, meaning that the scope of the social assessment covered from the extraction and processing of raw materials to the delivery of the finished product at the factory gate. acts for 26 social subcategories grouped into 5 categories. The SHDB offers a weighted aggregation model that converts the impact values of the social subcategories into aggregate impact values for each social category, which in turn can be aggregated into a single global social footprint for the products (the so-called Social Hotspot Index or SHI).

[1] Several references like UL, Environdec or Environment and Development Foundation were consulted. Main PCRs are not longer in force.

3 Social life cycle assessment

This deliverable 5.4 contains an evaluation of the social impacts of the four target products by using the Social Life Cycle Assessment (S-LCA) methodology.

S-LCA is one of three methodologies that have been developed to assess the sustainability of the three Pillars of organizations, products and services, focusing on the People Pillar. S-LCA is a methodology to assess the social impacts of products and services across their life cycle (e.g. from extraction of raw material to the end-of-life phase, e.g. disposal). S-LCA provides information on social and socio-economic aspects for decision-making, in the prospect to improve the social performance of an organization and ultimately the well-being of stakeholders.[1]

S-LCA rests upon a combination of methods, models, and data. Models are used to provide a representation of the product life cycles/systems under study; several types of models can be used, e.g. a process model. Data is the information about the product life cycle/system and its potential impacts that enables the assessment to take place. Software tools can be used to apply methods, access generic data, and deliver summary reports with graphical layouts of the information processed.

In particular, the method and indicators of the Social Hotspot Database (SHDB) were used (Figure 4). The SHDB (which is available for software SimaPro) assesses 26 social sub-categories that can be grouped into 5 social categories. The SHDB offers a weighted aggregation model that converts the values of impacts for each social subcategory into aggregated impact values for each social category, which in turn can be aggregated until arriving at a single global social impact indicator (the so-called Social Hotspot Index).

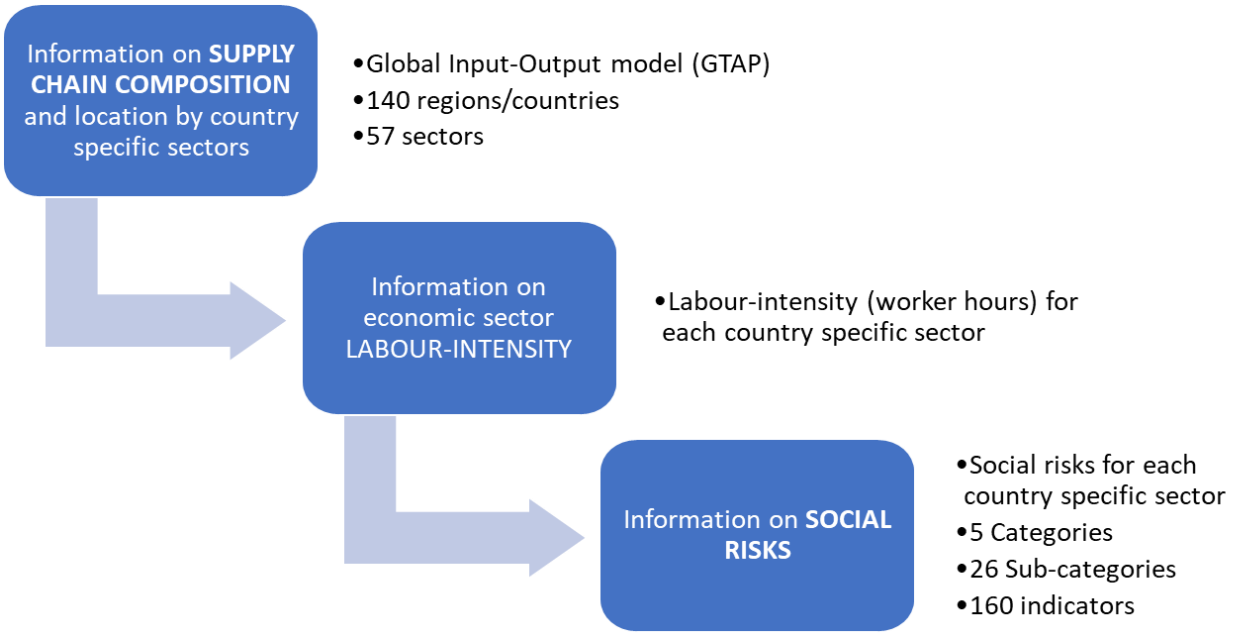

Figure 4. S-LCA methodology applied in the C-SERVEES project.

Figure 4 outlines the S-LCA methodology followed herein to develop the social studies of the target products. It includes the following steps and components:

Information on supply chain composition and location

Knowledge on where the production activities are taking place is a major consideration for S-LCA because of the influence of societal, political and cultural differences on the potential social impacts.[2–4] The first step in S-LCA is therefore to define the supply chain composition by describing how the production costs are distributed among the supply chain by country-specific sectors (CSS); i.e., how costs are allocated to each sector/country pair (e.g., Euros spent in electrical equipment sector in China).

A breakdown of the total manufacturing cost by CSS was provided by industry partners (ARÇELIK, LEXMARK and ADVA) for each target product, considering their Tier 1 level suppliers. The manufacturing costs were grouped into the following sectors in several countries (that were different depending on each product): plastic and rubber materials, ferrous metals, non-ferrous metals, paper products, mineral products, electronic equipment and wood (only in some cases for packaging).

The SHDB incorporates a Global Input-Output model that provides information on the trade flows between the economic sectors of each country or region of the world (including 57 sectors in 140 regions/countries). The so-called GTAP (Global Trade Analysis Project) model was used to complete the definition of the supply chain composition for the target products by modelling how the economic amounts purchased from the CSS related to Tier 1 suppliers are contributed by other CSS (related to lower-Tier suppliers).

Information on the economic sector labour-intensity

Labour-intensity, expressed in terms of worker-hours, plays the role of what environmental LCA refers to as an 'elementary flow'; i.e., the basic or first-order 'intervention' by a production process that ultimately is linked to outcomes or impacts of interest. More generally, worker hours are relevant because they represent evidence of the intensity of work required by each CSS directly related to production.[2,3]

The SHDB provides a worker-hours model that is based on average wage payments for each sector in each of the GTAP country/region. Thus, the SHDB was used to identify how many worker-hours are involved for each CSS involved in the supply chain of the target products, according to the economic demands from each CSS quantified in the previous step.

Information on social risks

The SHDB also provides information on social risks and opportunities by country and economic sector, including over 160 social impact indicators for the CSS covered by the GTAP model. 26 impact subcategories (Figure 5) can thus be assessed by several indicators depending on the data context; sometimes only one indicator is available and relevant and sometimes several indicators are used for a specific social subcategory. The interpretation of data and the determination of risk levels (from low to very high) are most often performed through consideration of the range and distribution of values exhibited for the indicators across the full population of sectors and countries.[2,3]

The labour-intensity information for each CSS can be used together with the social risk levels there to determine how many worker-hours are linked to the social risk level for a given social subcategory in each CSS.

Social Hotspot Index (SHI)

The SHDB database includes information on 160 indicators covering 26 impact subcategories, 5 impact categories and 4 stakeholder groups: workers, local communities, value chain actors and society (Figure 5). [2,3]

Due to the large number of indicators and impact subcategories used and considering the specific evaluation for each country and economic sector, the S-LCA generates a large amount of data on social impacts that makes difficult to base decisions on. Therefore, to facilitate the understanding of the results and make sense of the social impact information available for each CSS, the Social Hotspot Index (SHI) was created and it has been used in several studies.[2,4,5]

Figure 5. Social categories and subcategories included in the S-LCA (using SHDB).

The SHI is an impact assessment method that combines the labour-intensity information with the social risk levels to express social risks (and opportunities) in terms of medium risk hours equivalent (Mrheq), by sector and country for the 5 social impact categories and the 26 social impact subcategories. The SHI is determined by first weighing the level of risk identified for each social impact subcategory, using weighting factors shown in Table 5. This weighting augments or lower the number of workers-hours depending on the risk level, converting them into Mrheq. Thus, the same unit is used to calculate the impact on each social subcategory, so the impacts for different subcategories can be aggregated into single impact values for the corresponding social categories, which in turn can be aggregated into a single global social impact indicator, namely the so-called Social Hotspot Index or SHI. In the method, social subcategories and categories are all weighted equally when adding them together (i.e., they are all given the same relevance).

Table 5. SHDB Impact Assessment method. Weighting factors used by default.[2,3]

Risk level	Weighting factor
Very high risk	10
High risk	5
Medium risk	1
Low risk	0.1

The expression of social impacts in Mrheq was also applied herein to aggregate the social impacts into a social footprint given by the SHI, which was calculated using the SHDB in combination with SimaPro software. Furthermore, it was helpful to identify target areas in the supply chains to improve social conditions, i.e., social hotspots or individual production activities/countries (identified by CSS) that contribute most to the risk (overall and/or by impact category or subcategory).

4 Washing machine

The washing machine selected for demonstration as the Reference product is GRUNDING C-SERVEES (7150370100), which has 9 kg capacity, energy efficiency class A^{+++} and connectivity features. It is manufactured in Çayırova (Turkey) and currently sold in Europe (especially Spain) and Turkey. ARÇELIK selected this model for its smart home technology, which allows the users to access the HomeWhiz app from their smartphones or tablets and control the smart features of the product (switch on/off, program selection, user instructions, etc.). By using connected products, ARÇELIK had a chance to collect data and learn customer usage habits to improve customers' experience and offer maintenance and repair services to extend product life. More details on the current washing machine selected for demonstration are shown in Table 6.

Table 6. Technical specifications of the demo washing machine.

MODEL	**ARÇELIK 9123 WF**
Image	
Product number	7150370100
Colour	White
Size	840 mm × 600 mm × 610 mm
Weight	75 (±4) kg
Capacity	9.0 kg
Max. spin speed	1,200 rpm
Fascia	Grundig
Dynamic group	Large
Number of programs	16
Features	HomeWhiz, ProSmart (Brushless Motor with 10-year guarantee), Wi-Fi and BLE, Steam Function, Anticrease+
Energy class	A^{+++} (-30%)
Electricity consumption per year	148 kWh
Water consumption per year	10,318 L
Country of origin	Turkey

The activities conducted in the LCSA were derived from the WASH-CIRCMODE short-term actions validated in WP2. The table below presents the WASH-CIRCMODE canvas sub-components and their validated short-term CE actions, as presented in Table 24 in D2.2, and the selected strategies implemented in WP5 as C-SERVEES product (Product number 7150341600).

Table 7. Validated short-term WASH-CIRCMODE Canvas Key Circular sub-components and their associated Circular Economy Actions relevant for the LCSA.

WASH-CIRCMODE Canvas Sub-Component	WASH-CIRCMODE validated short-term Circular Economy Actions	LCSA implemented
WASH_C1.1 Diversify circular activities	WASH_A1.1.1 Increase recycled plastic content in washing machine's components	Eco-PP inner cover and detergent box group
WASH_C1.2 Embrace eco design to ensure products circularity across life-cycle ages	WASH_A1.2.1 Use novel formula to increase recycled PET content in the washing machine's tub to make it more durable	Recycled PET TUB
WASH_C2.3 Introduce and/or expand the use of ICT to foster circular economy	WASH_A2.3.2 Use QR codes to provide information about washing machine's materials and company's circularity	
WASH_A1.3.1 Enhance the integration of circular strategies into the production process	Blowing agent inner cover and detergent box group	Mass reduction in tub, inner cover and detergent box group

4.1 Functional unit and system boundaries

The product function for the washing machine is washing clothes, which has 9 kg capacity and it results in 24,750 kg of clothes washed during its 12.5-year lifetime (assuming 220 washing cycles/year). The assessment was initially performed for one product and at the end converted to the functional unit. Table 8 shows the system boundaries considered for the washing machine, identifying the life cycle phases, processes and other elementary flows included and excluded in the study.

Table 8. System boundaries considered for the washing machine.

Life cycle phase	Included	Excluded
Raw material extraction and processing	Extraction of natural resources Refining and raw material production Intermediate product manufacturing Waste treatment and transport	Infrastructure
Product manufacturing	Energy for product manufacturing/assembly Transport	Infrastructure Production losses

4.2 Reference WM social life cycle assessment

4.2.1 Social life cycle inventory

Primary data provided by ARÇELIK was used as the starting point to carry out the S-LCA. Specifically, it provided economic data describing the supply chain composition and location, identifying all the economic costs required to produce the washing machine and the cost breakdown by countries and economic sectors. Table 9 shows the percentage breakdown of total production costs by countries and sectors.

Table 9. Production cost breakdown for the Reference washing machine by countries and economic sectors.

Country/Sector	Plastic products	Ferrous metals	Non-ferrous metals	Paper products	Mineral products	Electronic equipment	Oil	Manufacturing process
TOTAL	28.591%	13.461%	3.955%	0.391%	2.748%	31.573%	0.031%	19.251%

Turkey	26.575%	10.645%	3.955%	0.391%	1.299%	27.947%	0.031%	19.251%
Germany						0.234%		
China		1.937%				0.752%		
Poland	0.955%							
Slovenia		0.878%				0.540%		
Italy					1.449%			
Taiwan	0.411%					2.100%		
UK	0.650%							

The sectors included in the assessment comprise those related to every material and/or component required to produce the washing machine, as well as the sector linked to the manufacturing process at ARÇELIK facilities (i.e., electronic equipment sector in Turkey). Electronic equipment and plastics are the most complex sectors in the supply chain since the related components come from 5 and 4 different countries, respectively. Turkey is clearly the most important country in the washing machine value chain, since 90% of the total production costs is spent there.

The SHDB method and datasets were then used to calculate the social impacts for each sector in each country. The Social Hotspot 2019 Category Method with Weights (which is available for SimaPro software) was used. The social impacts derived from the washing machine were obtained by allocating the production costs (in USD) to the corresponding social LCI datasets for every country-specific sector involved in the washing machine supply chain. The social LCI datasets used are listed in Table 10.

Table 10. Social LCI datasets for the country-specific sectors linked to the Reference washing machine.

Social Hotspot Database (SHDB)	Reference Unit
Chemical, rubber, plastic products/TUR S	USD
Chemical, rubber, plastic products/POL S	USD
Chemical, rubber, plastic products/TWN S	USD
Chemical, rubber, plastic products/GBR S_UK	USD
Ferrous metals/TUR S	USD
Ferrous metals/CHN S_China	USD
Ferrous metals/SVN S	USD
Metal products/TUR S	USD
Paper products, publishing/TUR S	USD
Mineral products nec/TUR S	USD
Mineral products nec/ITA S	USD
Electronic equipment/TUR S	USD
Electronic equipment/DEU S_Germany	USD
Electronic equipment/CHN S_China	USD
Electronic equipment/SVN S	USD
Electronic equipment/TWN S	USD
Oil/TUR S	USD
Manufactures nec/TUR S	USD

4.2.2 Social life cycle impact assessment

The social footprint of the washing machine was calculated by aggregating the social impacts associated with each country-specific sector listed in Table 10 into a single social impacts indicator, namely the so-called Social Hotspot Index (SHI). Table 11 shows the SHI obtained for the washing machine, as well as its breakdown into the different social impact categories that contribute to the total social footprint.

Table 11. Social impacts of the Reference washing machine by impact category.

Social category	Total impact (Pt)
Labour Rights & Decent Work	662.99
Health & Safety	794.55
Human Rights	460.75

Governance	1,045.95
Community	387.92
TOTAL: SHI	**3,352.16**

Figure 6 shows graphically the contribution of each social impact category to the total social footprint of the washing machine. It can be found that the greatest social impacts are due to Governance and Health & Safety issues, while social impacts affecting Community have the lowest contribution.

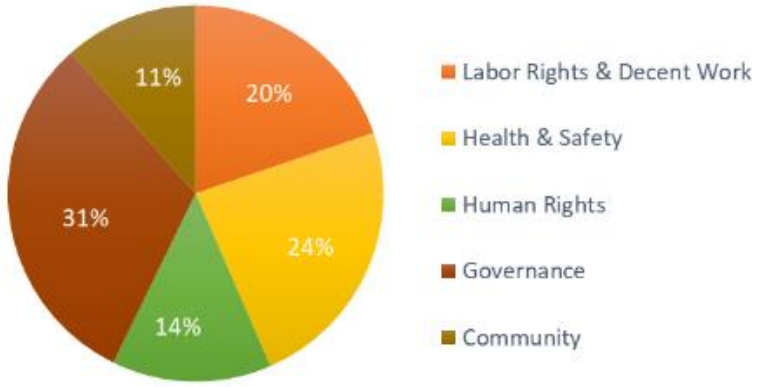

Figure 6. Percentage of impact categories in the social life cycle assessment for the Reference washing machine.

Social impacts by economic sectors

Figure 7 shows the economic share of each productive sector in the washing machine supply chain. The economic sector with the highest contribution (i.e., that in which the company spent more money to produce the washing machine) is the electronic equipment sector, followed by the plastics sector and the EEE manufacturing process (performed in ARÇELIK facilities). In contrast, oil and paper products are the economic sectors where expenditures are the lowest.

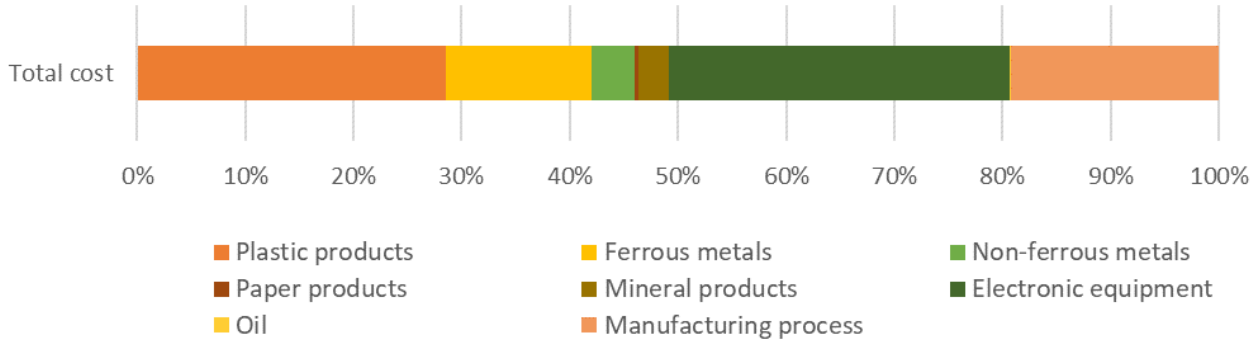

Figure 7. Production cost breakdown for the Reference washing machine by economic sectors.

The social impacts were assessed for every economic sector. Table 12 shows the impacts for each social category obtained for each sector involved in the washing machine supply chain, while Figure 8 shows graphically the contribution by each sector to the total impact in each social category. The results show that the electronic equipment sector, which is related to the electronic components used in the washing machine, comprises most of the impact for every social category, ranging between 41% and 48% of total social impact depending on the social category. The impact contribution of the electronic equipment sector is high compared to its economic share in total production costs, which is around 32%, meaning that the social risk levels in this sector are high compared with other sectors in the washing machine supply chain. The social impacts of the plastic products, ferrous metals and manufacturing process conducted in ARÇELIK facilities (Turkey) also have relevant contributions to social impacts. However, it should be noted that the impact

contribution of these sectors is aligned with their economic shares in total production costs, so their social risk levels are acceptable. Oil, paper and mineral products have negligible social impacts when compared to the other economic sectors composing the washing machine supply chain.

Table 12. Social impacts of the Reference washing machine by economic sectors.

Economic sector	Labour Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
Plastic products	112.71	120.03	88.31	191.47	74.08
Ferrous metals	82.12	108.06	61.11	141.99	49.25
Non-ferrous metals	22.18	27.28	15.43	35.73	12.70
Paper products	1.85	2.01	1.28	2.92	1.14
Mineral products	7.65	10.62	5.89	12.46	4.79
Electronic equipment	296.39	382.93	185.18	429.80	157.70
Oil	0.09	0.15	0.07	0.18	0.07
Manufacturing	140.01	143.46	103.48	231.42	88.20
TOTAL, Pts	**662.99**	**794.55**	**460.75**	**1,045.95**	**387.92**

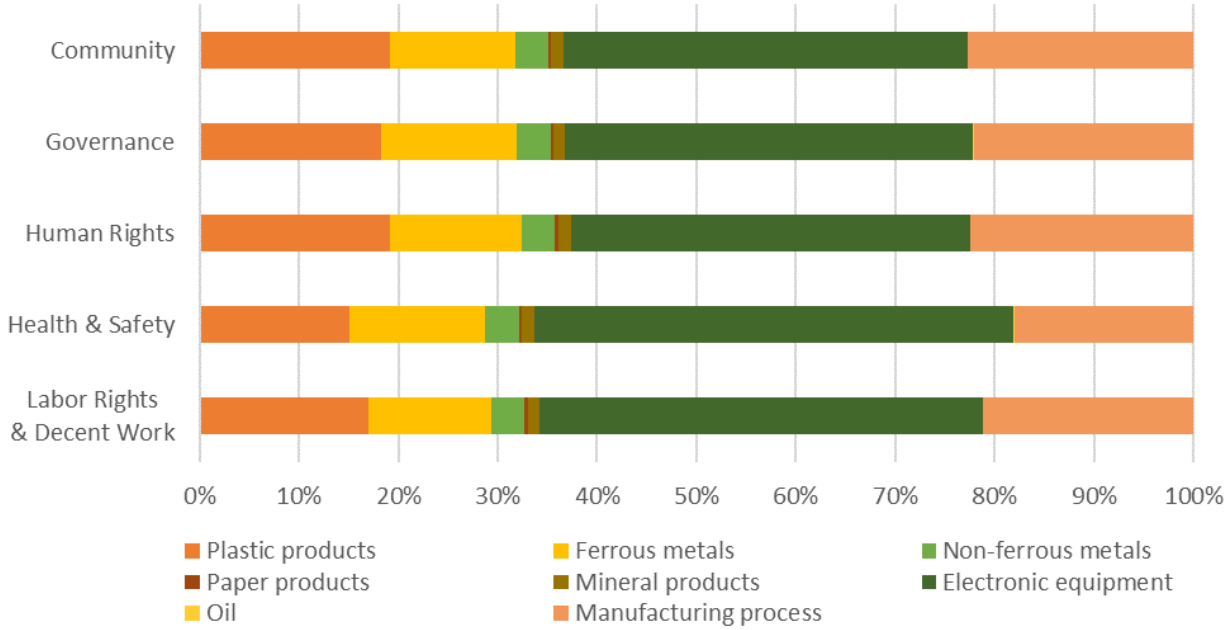

Figure 8. Contribution of each economic sector to the total social impacts of the Reference washing machine by social category.

Social impacts by countries

Figure 9 shows the economic share of each country in the washing machine supply chain. The country with the highest contribution by far is Turkey, comprising about 90% of the total washing machine production costs. It includes both the manufacturing costs at ARÇELIK facilities and the purchasing costs of various materials and components (especially plastic products, ferrous metals and electronic components) from other companies located in Turkey as well. The expenditure in the rest of countries is very low in comparison; e.g., China and Taiwan are the second and third countries with the largest contributions to total production costs, but these are less than 3% each.

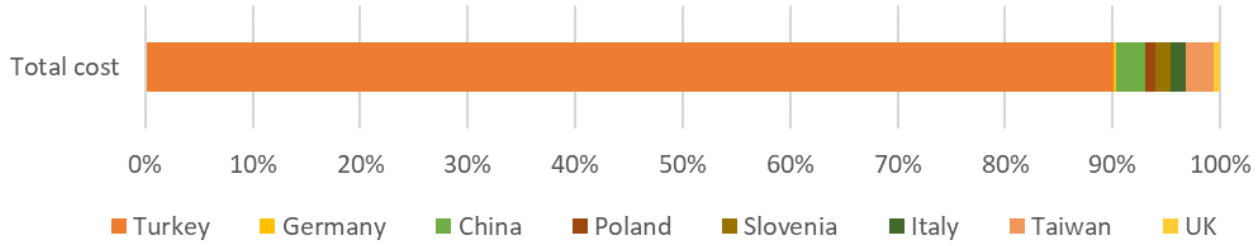

Figure 9. Production cost breakdown for the Reference washing machine by country.

The social impacts were also assessed for every country in the washing machine supply chain. Table 13 shows the impacts for each social category obtained for each country, while Figure 10 shows graphically the contribution by each country to the total impact in each social category.

The results show that Turkey is the country with the highest social impacts for all social categories, ranging between 91% and 93% of the total washing machine impacts depending on the social category assessed. These results were expected since 90% of the total washing machine production costs take place there, either in ARÇELIK factory or in the facilities of other Turkish companies supplying materials or components. ARÇELIK should therefore prioritise opportunities and measures together its Turkish suppliers (especially those in electronic equipment sector) to apply social improvements there, which could in turn derive in a decrease of the social footprint of the washing machine.

China also shows relevant contributions to total social impacts, although these are much lower than those from Turkey. Despite China and Taiwan have similar shares in total production costs, the social impacts in China are between 2 and 5 times greater than in Taiwan. This reveals that social risk levels in the Chinese productive sectors supplying ARÇELIK are high, so they can be identified as social hotspots of the washing machine. ARÇELIK could also investigate opportunities and measures for social improvements there.

Table 13. Social impacts of the Reference washing machine by country.

Economic sector	Labour Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
Turkey	614.48	726.56	422.81	968.02	360.70
Germany	0.49	0.89	0.38	0.62	0.24
China	30.35	43.09	22.30	54.51	17.79
Poland	2.11	3.49	1.72	2.92	0.94
Slovenia	3.04	7.53	1.89	3.49	1.61
Italy	2.14	3.42	1.89	3.12	1.33
Taiwan	9.37	8.15	9.06	12.01	4.52
UK	1.01	1.42	0.69	1.27	0.79
TOTAL, Pts	**662.99**	**794.55**	**460.75**	**1,045.95**	**387.92**

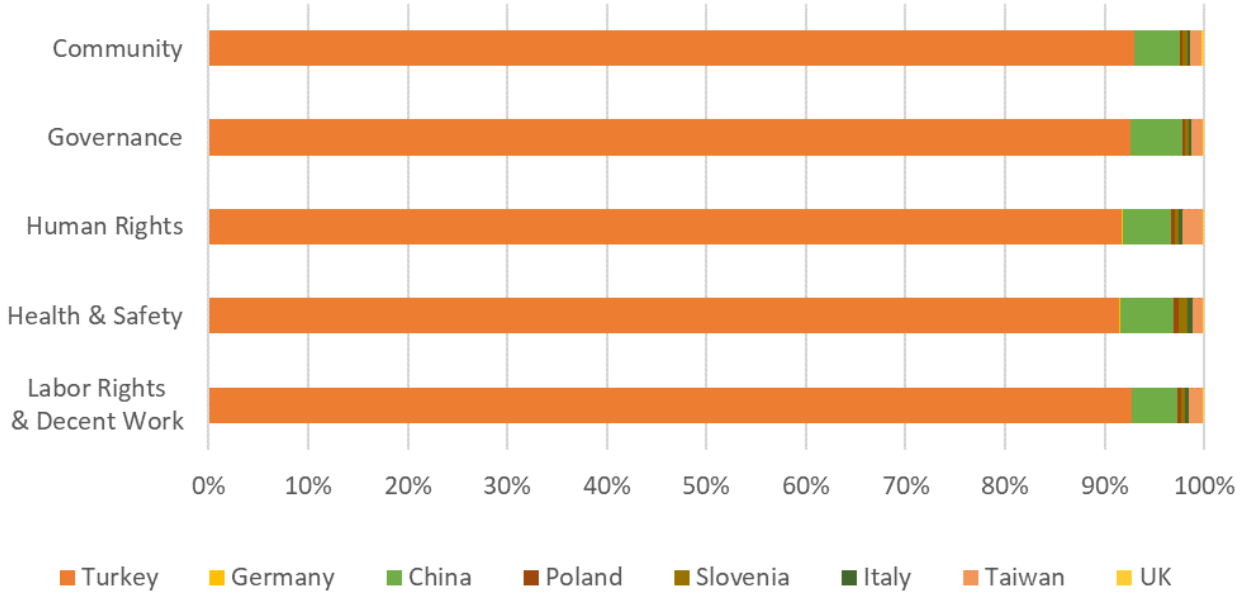

Figure 10. Contribution of each country to the total social impacts of the Reference washing machine by social category.

4.3 CSERVEES WM social life cycle assessment

4.3.1 Redesign changes

Redesign changes implemented in the LCSA as described in Table 7 are detailed in Table 14. Recycled materials are included for the inner door, the detergent box and the tub, as well as mass reduction of the tub and some less reductions in the inner cover and the detergent box.

Table 14. C-SERVEES WM changes.

	Reference	**C-SERVEES**
Product Number:	7150370100	7150341600
Lifetime	12.5 years	12.5 years
Functional units	2,750	2,750
Recycled content	No recycled materials	Inner door: 64% recycled
		Detergent box: 64% recycled
		Tub: 10% recycled
Mass reduction	No mass reduction	Reduction of 1 .09 kg in tub
		Reduction of 17 g in inner cover
		Reduction of 21 g in Detergent box

4.3.2 Social life cycle inventory

Primary data provided by ARÇELIK was used as the starting point to carry out the S-LCA. Specifically, it provided economic data describing the supply chain composition and location, identifying all the economic costs required to produce the washing machine and the cost breakdown by countries and economic sectors. Table 15 shows the percentage breakdown of total production costs by countries and sectors.

Table 15. Production cost breakdown for the C-SERVEES washing machine by countries and economic sectors.

Country/Sector	Plastic products	Ferrous metals	Non-ferrous metals	Paper products	Mineral products	Electronic equipment	Oil	Manufacturing process
TOTAL	28.591%	13.461%	3.955%	0.391%	2.748%	31.573%	0.031%	19.251%
Turkey	26.575%	10.645%	3.955%	0.391%	1.299%	27.947%	0.031%	19.251%
Germany						0.234%		
China		1.937%				0.752%		
Poland	0.955%							
Slovenia		0.878%				0.540%		
Italy					1.449%			
Taiwan	0.411%					2.100%		
UK	0.650%							

The sectors included in the assessment comprise those related to every material and/or component required to produce the washing machine, as well as the sector linked to the manufacturing process at ARÇELIK facilities (i.e., electronic equipment sector in Turkey). Electronic equipment and plastics are the most complex sectors in the supply chain since the related components come from 5 and 4 different countries, respectively. Turkey is clearly the most important country in the washing machine value chain, since 90% of the total production costs is spent there.

The SHDB method and datasets were then used to calculate the social impacts for each sector in each country (as explained in Section 3 of the main document). The Social Hotspot 2019 Category Method with Weights (which is available for SimaPro software) was used. The social impacts derived from the washing machine were obtained by allocating the production costs (in USD) to the corresponding social LCI datasets for every country-specific sector involved in the washing machine supply chain. The social LCI datasets used are listed in Table 16.

Table 16. Social LCI datasets for the country-specific sectors linked to the C-SERVEES washing machine.

Social Hotspot Database (SHDB)	Reference Unit
Chemical, rubber, plastic products/TUR S	USD
Chemical, rubber, plastic products/POL S	USD
Chemical, rubber, plastic products/TWN S	USD
Chemical, rubber, plastic products/GBR S_UK	USD
Ferrous metals/TUR S	USD
Ferrous metals/CHN S_China	USD
Ferrous metals/SVN S	USD
Metal products/TUR S	USD
Paper products, publishing/TUR S	USD
Mineral products nec/TUR S	USD
Mineral products nec/ITA S	USD
Electronic equipment/TUR S	USD
Electronic equipment/DEU S_Germany	USD
Electronic equipment/CHN S_China	USD
Electronic equipment/SVN S	USD
Electronic equipment/TWN S	USD
Oil/TUR S	USD
Manufactures nec/TUR S	USD

4.3.3 Social life cycle impact assessment

The social footprint of the washing machine was calculated by aggregating the social impacts associated with each country-specific sector listed in Table 16 into a single social impacts indicator, namely the so-called Social Hotspot Index (SHI). Table 17 shows the SHI obtained for the washing machine, as well as its breakdown into the different social impact categories that contribute to the total social footprint.

Table 17. SHDB - Social Hotspot 2019 Category Method w Weights for C-SERVEES washing machine.

	Labor Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
	Pt	Pt	Pt	Pt	Pt
TOTAL	662,99	794,55	460,75	1.045,95	387,92

Figure 11 shows graphically the contribution of each social impact category to the total social footprint of the washing machine. It can be found that the greatest social impacts are due to Governance and Health & Safety issues, while social impacts affecting Community have the lowest contribution.

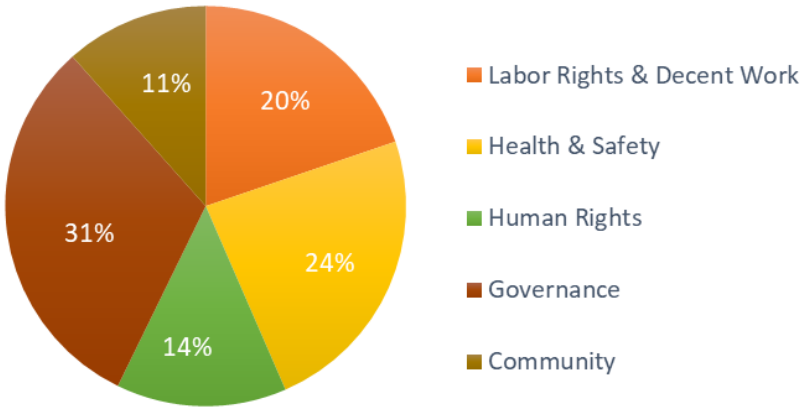

Figure 11. Social Life Cycle Assessment Impacts for the C-SERVEES washing machine.

Social impacts by economic sectors

Figure 12 shows the economic share of each productive sector in the washing machine supply chain. The economic sector with the highest contribution (i.e., that in which the company spent more money to produce the washing machine) is the electronic equipment sector, followed by the plastics sector and the EEE manufacturing process (performed in ARÇELIK facilities). In contrast, oil and paper products are the economic sectors where expenditures are the lowest.

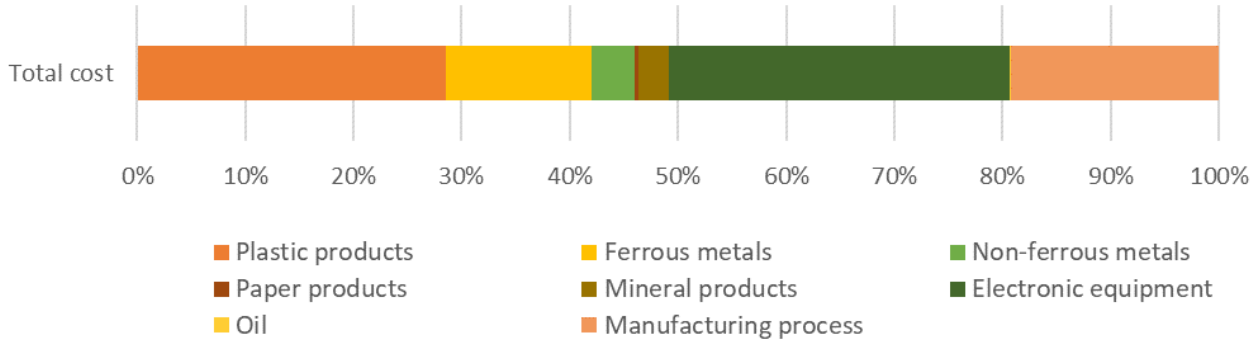

Figure 12. Production cost breakdown for the C-SERVEES washing machine by economic sectors.

The social impacts were assessed for every economic sector. Table 18 shows the impacts for each social category obtained for each sector involved in the washing machine supply chain, while Figure 13 shows

graphically the contribution by each sector to the total impact in each social category. The results show that the electronic equipment sector, which is related to the electronic components used in the washing machine, comprises most of the impact for every social category, ranging between 41% and 48% of total social impact depending on the social category. The impact contribution of the electronic equipment sector is high compared to its economic share in total production costs, which is around 32%, meaning that the social risk levels in this sector are high compared with other sectors in the washing machine supply chain. The social impacts of the plastic products, ferrous metals and manufacturing process conducted in ARÇELIK facilities (Turkey) also have relevant contributions to social impacts. However, it should be noted that the impact contribution of these sectors is aligned with their economic shares in total production costs, so their social risk levels are acceptable. Oil, paper and mineral products have negligible social impacts when compared to the other economic sectors composing the washing machine supply chain.

Table 18. Social impacts of the C-SERVEES washing machine by economic sectors.

Economic sector	Labour Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
Plastic products	112.71	120.03	88.31	191.47	74.08
Ferrous metals	82.12	108.06	61.11	141.99	49.25
Non-ferrous metals	22.18	27.28	15.43	35.73	12.70
Paper products	1.85	2.01	1.28	2.92	1.14
Mineral products	7.65	10.62	5.89	12.46	4.79
Electronic equipment	296.39	382.93	185.18	429.80	157.70
Oil	0.09	0.15	0.07	0.18	0.07
Manufacturing	140.01	143.46	103.48	231.42	88.20
TOTAL	**662.99**	**794.55**	**460.75**	**1,045.95**	**387.92**

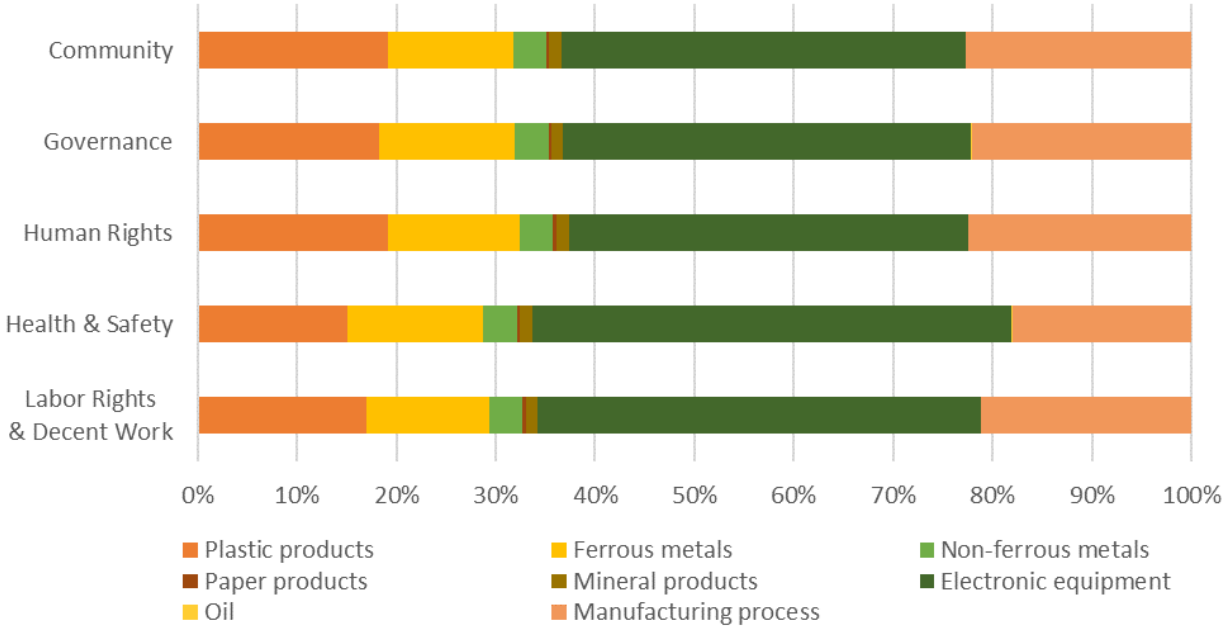

Figure 13. Contribution of each economic sector to the total social impacts of the C-SERVEES washing machine by social category.

Social impacts by countries

Figure 14 shows the economic share of each country in the washing machine supply chain. The country with the highest contribution by far is Turkey, comprising about 90% of the total washing machine production costs. It includes both the manufacturing costs at ARÇELIK facilities and the purchasing costs of various materials and components (especially plastic products, ferrous metals and electronic components) from other companies located in Turkey as well. The expenditure in the rest of countries is very low in comparison; e.g., China and Taiwan are the second and third countries with the largest contributions to total production costs, but these are less than 3% each.

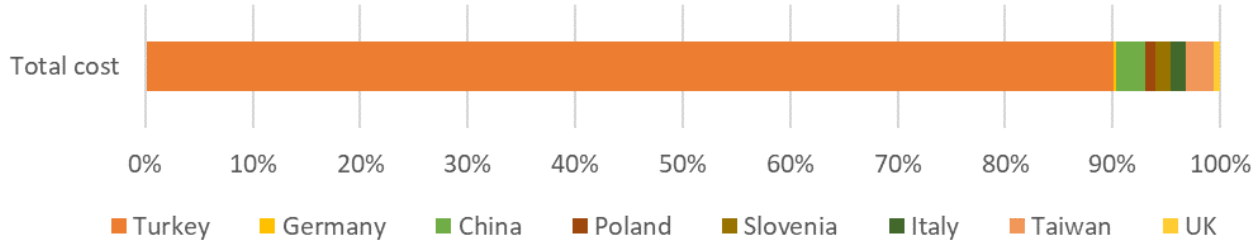

Figure 14. Production cost breakdown for the C-SERVEES washing machine by country.

The social impacts were also assessed for every country in the washing machine supply chain. Table 19 shows the impacts for each social category obtained for each country, while Figure 15 shows graphically the contribution by each country to the total impact in each social category.

The results show that Turkey is the country with the highest social impacts for all social categories, ranging between 91% and 93% of the total washing machine impacts depending on the social category assessed. These results were expected since 90% of the total washing machine production costs take place there, either in ARÇELIK factory or in the facilities of other Turkish companies supplying materials or components. ARÇELIK should therefore prioritise opportunities and measures together its Turkish suppliers (especially those in electronic equipment sector) to apply social improvements there, which could in turn derive in a decrease of the social footprint of the washing machine.

China also shows relevant contributions to total social impacts, although these are much lower than those from Turkey. Despite China and Taiwan have similar shares in total production costs, the social impacts in China are between 2 and 5 times greater than in Taiwan. This reveals that social risk levels in the Chinese productive sectors supplying ARÇELIK are high, so they can be identified as social hotspots of the washing machine. ARÇELIK could also investigate opportunities and measures for social improvements there.

Table 19. Social impacts of the C-SERVEES washing machine by country.

Economic sector	Labour Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
Turkey	614.48	726.56	422.81	968.02	360.70
Germany	0.49	0.89	0.38	0.62	0.24
China	30.35	43.09	22.30	54.51	17.79
Poland	2.11	3.49	1.72	2.92	0.94
Slovenia	3.04	7.53	1.89	3.49	1.61
Italy	2.14	3.42	1.89	3.12	1.33
Taiwan	9.37	8.15	9.06	12.01	4.52
UK	1.01	1.42	0.69	1.27	0.79
TOTAL	**662.99**	**794.55**	**460.75**	**1,045.95**	**387.92**

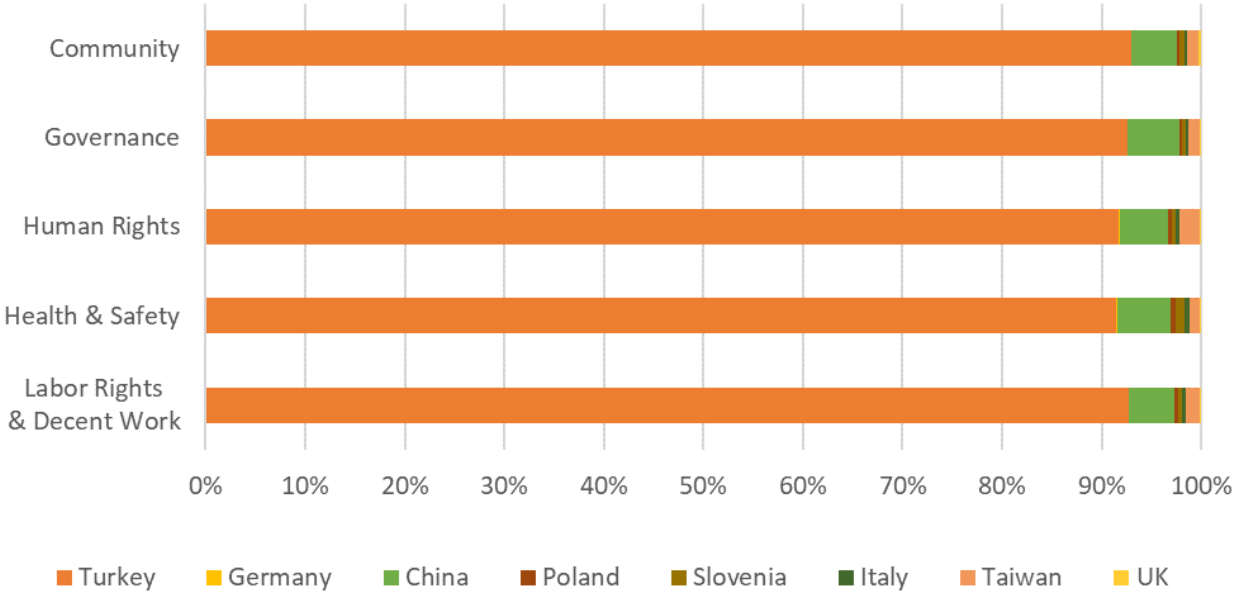

Figure 15. Contribution of each country to the total social impacts of the C-SERVEES washing machine by social category.

4.4 WM comparative social life cycle assessment

Circularity enhancement of the washing machine is performed with the same amount and cost breakdown as the linear washing machine. Consequently, the C-SERVEES washing machine and the reference washing machine have the same social impact, see Table 20 and Figure 16 for a comparative S-LCA for one washing cycle.

Table 20. Washing machines comparative S-LCA for one washing cycle.

Units: Pts	Reference	C-SERVEES	Relative reduction
Labor Rights & Decent Work	0.24	0.24	0.0%
Health & Safety	0.29	0.29	0.0%
Human Rights	0.38	0.38	0.0%
Governance	0.14	0.14	0.0%
Community	1.22	1.22	0.0%

Figure 16. Washing machines comparative S-LCA.

5 Multifunctional laser printer

LEXMARK identified and selected several laser printer models to include in the demonstration, such as the following models: CX860dte, X950de, MS812 and CX510. All of them are multifunctional laser printers that were selected due to their suitability for refurbishment operations.

The laser printer selected as the reference for the life cycle sustainability assessment was the LEXMARK CX860dte. It is a network-ready, professional multi-function device with standard 2-sided printing and scanning, a 1.6 GHz quad-core processor and 2GB of standard memory that prints at up to 60 ppm black and colour. The printer fuses different colours to a medium (such as paper) to create hard copy images from electronic or hard copy originals. The printer product delivered to the customer consists of the printer, a power cord, printed setup instructions, a CD/DVD that includes the User Guide and Printer Drivers and an initial set of product supplies. The printer is delivered in packaging that can be recycled locally and is not needed for product operation. Product supplies include toner cartridges, imaging kits and the fusing mechanism. The power supply is internal to the product and the imaging kit and fusing mechanism are installed at the factory. Only the toner cartridges must be installed by the customer. More details on the current multifunctional laser printer selected for the sustainability assessment are shown in Table 21.

The functional unit considered in the present study is 1,000 printed pages with the one multifunctional laser printer LEXMARK CX860dte. The performance of this laser printer is 390,000 pages printed during its 5-year lifetime (assuming a standard business usage of 260 days/year and 300 pages per day). It should be noted that this product is a shared printing and copying device that is used by a pool of business users. The assessment was initially performed for one product and at the end converted to the functional unit.

Table 21. Technical specifications of the demo multifunctional laser printer.

MODEL	**LEXMARK CX860dte**
Image	
Product number	42K0071
Print technology	Colour Laser
Functions	Colour copying, colour faxing, colour printing, colour scanning, colour network scanning
Display	Lexmark e-Task 10-inch (25 cm) class colour touch screen
Size / Packaged size	1162 x 559 x 588 mm / 1380 x 762 x 830 mm
Weight / Packaged weight	131.3 kg / 157.4 kg
Print speed (up to)	Black: 60 ppm / Colour: 60 ppm (pages per minute)
Recommended monthly page volume	5,000 - 50,000 pages
Laser cartridges yield (up to)	55,000-page Black and Colour (CMYK) Ultra High Yield Cartridges

	22,000-page Colour (CMY) Extra High Yield Cartridges 33,000-page Black Extra High Yield Cartridge 17,000-page Colour (CMY) High Yield Cartridges 8,000-page Black and Colour (CMYK) Cartridges
Photoconductor estimated yield (up to)	175,000 pages, based on 3 average letter/A4-size pages per print job and ~ 5% coverage
Developer unit(s) estimated yield (up to)	300,000 pages, based on 3 average letter/A4-size pages per print job and ~ 5% coverage
Cartridge(s) Shipping with Product	8,000-page Black Return Program Toner Cartridge 17,000-page Colour (CMY) High Yield Return Program Toner Cartridges
Electricity consumption	0.391 kWh/1,000 pages (ENERGY STAR Certified)
Average power	0.3 W (Hibernate Mode), 3.3 W (Sleep Mode), 125 W (Ready Mode), 870 W (Printing), 650 W (Copying), 115 W (Scanning)
Country of origin	China

The activities conducted in the LCSA were derived from the PRINT-CIRCMODE short-term actions validated in WP2. The table below presents the PRINT-CIRCMODE canvas sub-components and their validated short-term CE actions, as presented in Table 24 in D2.3, and the selected strategies implemented in WP5 as C-SERVEES product.

Table 22. Validated short-term PRINT-CIRCMODE Canvas Key Circular sub-components and their associated Circular Economy Actions relevant for the LCSA.

PRINT-CIRCMODE Canvas Sub-Component	**PRINT-CIRCMODE validated short-term Circular Economy Actions**	**LCSA implemented**
PRINT_C2.3 Introduce and/or expand the use of ICT to foster circular economy	PRINT_A2.3.1 Use ICT to support information sharing across the supply chain related to recycled content	Remanufacturing
PRINT_C1.1 Diversify circular activities	PRINT_A1.1 2 Identify levers to reduce dismantling and refurbishing cost by setting various operating models	
PRINT_C1.5 Provide repair and maintenance services, including new technologies such as 3D printing	PRINT_A1.5.2 Salvage working and repairable parts from collected/return printers and use on E2N (Equal to New) printers	
PRINT_C1.6 Optimize end-of-life circularity	PRINT_A1.6.1 increase the flow of returned end-of-life printers by reducing the associated time and cost	
PRINT_C2.3 Introduce and/or expand the use of ICT to foster circular economy	PRINT_A2.3.1 Use ICT to support information sharing across the supply chain related to recycled content	
PRINT_C9.4 Implement and/or enhance strategies and/or practices to address the challenges of promoting options with lower lifetime rather than lower initial costs	PRINT_A9.4.2 Investigate economics of more CE suitable materials coming from end-of-life cartridges or printers	Remanufacturing toner cartridges

5.1 Functional unit and system boundaries

The main product function for the multifunctional laser printer (MLP) is to create hard copy images from electronic or hard copy originals by fusing different colours to a medium like paper. The product considered in this study is one multifunctional laser printer LEXMARK CX860dte, which has a maximum printing speed of 60 pages per minute and results in 390,000 pages printed during its 5-year lifetime (assuming a standard business usage of 260 days/year and 300 pages per day).

Table 23 shows the system boundaries considered for the laser printer, identifying the life cycle phases, processes and other elementary flows included and excluded in the study.

Table 23. System boundaries considered for the laser printer.

Life cycle phase	Included	Excluded
Raw material extraction and processing	Extraction of natural resources Refining and raw material production Intermediate product manufacturing Waste treatment and transport	Infrastructure
Product manufacturing	Energy for product manufacturing/assembly Transport	Infrastructure Production losses Packaging

5.2 Reference MLP social life cycle assessment

5.2.1 Social life cycle inventory

Primary data provided by LEXMARK was used as the starting point to carry out the S-LCA. Specifically, it provided economic data describing the supply chain composition and location, identifying all the economic costs required to produce the laser printer and the cost breakdown by countries and economic sectors. LEXMARK provided primary data for a series of components that account all together for 95 kg. The social impacts were extrapolated to China, for each economic sector, taking into account their respective weights in the laser printer. Table 24 shows the percentage breakdown of total production costs by countries and sectors.

Table 24. Production cost breakdown for the Reference MLP by countries and economic sectors.

Country/Sector	Plastic products	Ferrous metals	Non-FE metals	Paper products	Mineral products	Electronic equipment	Manufacturing process
TOTAL	24.31%	18.58%	1.69%	0.19%	1.97%	30.16%	23.10%
China	22.28%	18.31%	1.69%	0.19%	1.25%	21.54%	23.10%
USA	0.06%	0.01%				4.30%	
Japan	1.93%					0.52%	
Germany		0.09%				0.01%	
Philippines						2.11%	
South Korea					0.72%	1.43%	
Thailand		0.16%				0.25%	
Singapore	0.04%						

The sectors included in the assessment comprise those related to every material and/or component required to produce the laser printer, as well as the sector linked to the manufacturing process at LEXMARK facilities (i.e., electronic equipment sector in China). Electronic equipment is the most complex sector in the supply chain since the related components come from 7 different countries, being China the country where more money is spent in electronic components. By countries, China is by far the most important in the acquisition of materials and components, representing around 88% of total production costs for the laser printer. It is followed by USA, although its contribution is much more limited with about 4% of total production costs.

The SHDB method and datasets were then used to calculate the social impacts for each sector in each country (as explained in Section 3 of the main document). The Social Hotspot 2019 Category Method with Weights (which is available for SimaPro software) was used. The social impacts derived from the laser printer were obtained by allocating the production costs (in USD) to the corresponding social LCI datasets for every country-specific sector involved in the laser printer supply chain. The social LCI datasets used are listed in Table 25.

Table 25. Social LCI datasets for the country-specific sectors linked to the Reference MLP.

Social Hotspot Database (SHDB)	Reference Unit
Chemical, rubber, plastic products/CHN S	USD
Chemical, rubber, plastic products/USA S	USD
Chemical, rubber, plastic products/JPN S	USD
Chemical, rubber, plastic products/SGP S	USD
Electronic equipment/CHN S China	USD
Electronic equipment/USA S	USD
Electronic equipment/JPN S Japan	USD
Electronic equipment/DEU S Germany	USD
Electronic equipment/PHL S	USD
Electronic equipment/KOR S SouthKorea	USD
Electronic equipment/THA S Thailand	USD
Ferrous metals/CHN S China	USD
Ferrous metals/USA S	USD
Ferrous metals/DEU S Germany	USD
Ferrous metals/THA S	USD
Metals nec/CHN S China	USD
Paper products, publishing/CHN S China	USD
Mineral products nec/CHN S China	USD
Mineral products nec/KOR S	USD
Manufactures nec/CHN S	USD

5.2.2 Social life cycle impact assessment

The social footprint of the laser printer was calculated by aggregating the social impacts associated with each country-specific sector listed in Table 25 into a single social impacts indicator, namely the so-called Social Hotspot Index (SHI). Table 26 shows the SHI obtained for the laser printer, as well as its breakdown into the different social impact categories that contribute to the total social footprint.

Table 26. Social impacts of the Reference MLP by impact category.

Social category	Total impact (Pt)
Labour Rights & Decent Work	13,696.17
Health & Safety	19,321.16
Human Rights	9,917.50
Governance	23,975.84
Community	8,052.91
TOTAL: SHI	**74,963.58**

FigFigure 17 shows graphically the contribution of each social impact category to the total social footprint of the laser printer. It can be found that the greatest social impacts are due to Governance and Health & Safety issues, while social impacts affecting Community have the lowest contribution.

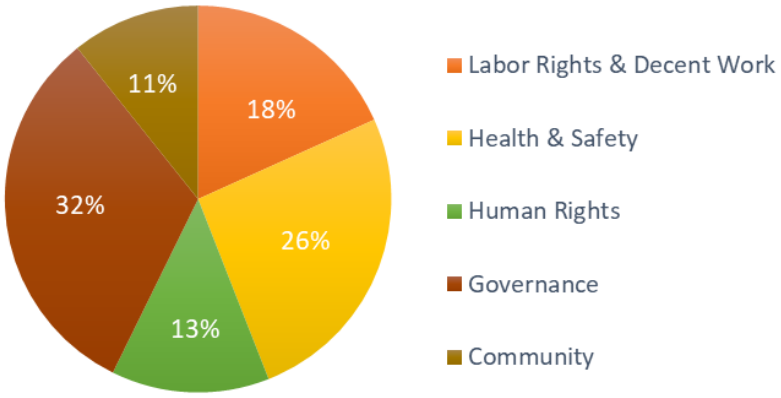

Figure 17. Percentage of impact categories in the social life cycle assessment for the Reference MLP.

Social impacts by economic sectors

Figure 18 shows the economic share of each productive sector in the laser printer supply chain. The economic sector with the highest contribution (i.e., that in which the company spent more money to produce the laser printer) is the electronic equipment sector, followed by the EEE manufacturing process (performed in LEXMARK facilities) and the sectors related to plastic products and ferrous metals. In contrast, paper products and non-ferrous metals are the economic sectors where expenditures are the lowest.

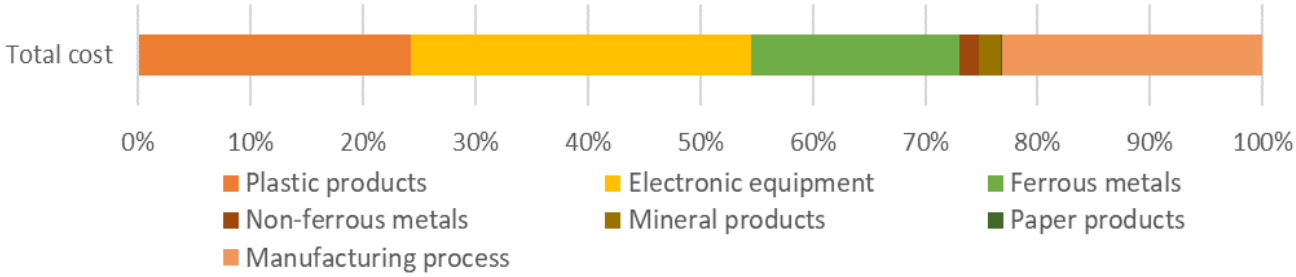

Figure 18. Production cost breakdown for the Reference MLP by economic sectors.

The social impacts were assessed for every economic sector. Table 27 shows the impacts for each social category obtained for each sector involved in the laser printer supply chain, while Figure 19 shows graphically the contribution by each sector to the total impact in each social category. The results show that the manufacturing process used to produce the laser printer comprises most of the impact for every social category, ranging between 28% and 29% of total social impacts depending on the social category assessed. The impact contribution of the manufacturing process is therefore slightly higher than its economic share in total production costs, which is around 23%. This means that the laser printer manufacturing process, which takes place in China, constitutes a social hotspot to be prioritised when planning measures to improve social conditions and reduce the social footprint of the laser printer.

There are other economic sectors showing relevant contributions to total social impacts, such as electronic equipment (24-27% contribution to total impacts), plastic products (24-25%) and ferrous metals (17-18%). The impact contributions of these sectors are completely aligned to their respective economic shares in total production costs, so their social risk levels are tolerable (i.e., social improvements could be applied there due to their large contribution to social impacts, but the priority is lower).

Mineral products, non-ferrous metals and paper products have negligible social impacts when compared to the other economic sectors composing the laser printer supply chain.

Table 27. Social impacts of the Reference MLP by economic sectors.

Economic sector	Labour Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
Plastic products	3,349.12	4,699.44	2,436.02	5,924.03	2,014.11
Electronic equipment	3,740.40	5,025.66	2,562.90	6,040.52	1,961.42
Ferrous metals	2,327.11	3,436.87	1,826.90	4,415.84	1,466.61
Non-ferrous metals	214.47	308.63	165.60	395.22	134.23
Mineral products	208.52	314.44	144.50	354.57	112.86
Paper products	32.12	46.26	22.78	56.98	18.76
Manufacturing	3,824.44	5,489.87	2,758.80	6,788.68	2,344.93
TOTAL	**13,696.17**	**19,321.16**	**9,917.50**	**23,975.84**	**8,052.91**

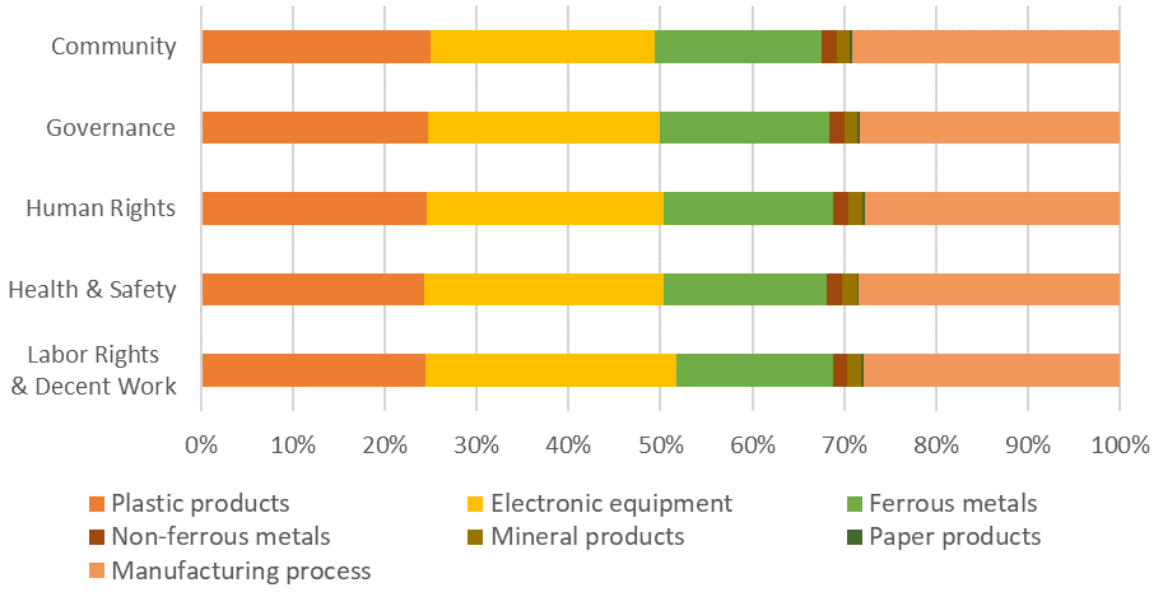

Figure 19. Contribution of each economic sector to the total social impacts of the Reference MLP by social category.

Social impacts by countries

Figure 20 shows the economic share of each country in the laser printer supply chain. The country with the highest contribution is China, comprising about 88% of the total laser printer production costs. It includes both the manufacturing costs at LEXMARK facilities and also the purchasing costs of various materials and components (especially plastic products, ferrous metals and electronic components) from other companies located in China as well. The expenditure in the rest of countries involved in the supply chain is very low in comparison. Nonetheless, the contribution to total production costs of some countries is still relevant, such as USA (4.4%), Japan (2.5%), Philippines (2.1%) and South Korea (2.1%), whereas the contribution of other countries is negligible.

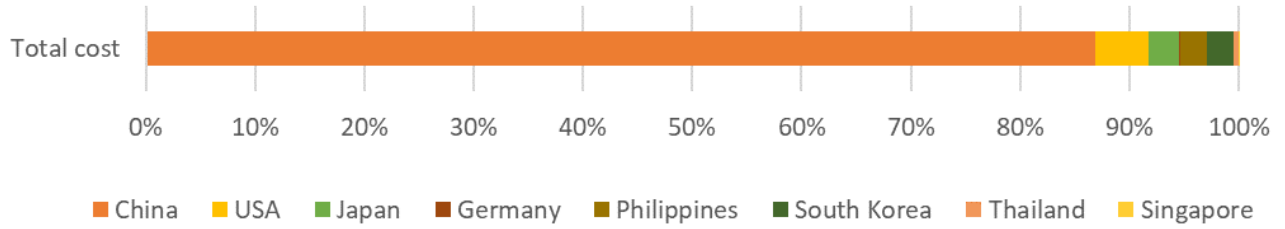

Figure 20. Production cost breakdown for the Reference MLP by country.

The social impacts were also assessed for every country in the laser printer supply chain. Table 28 shows the impacts for each social category obtained for each country, while Figure 21 shows graphically the contribution by each country to the total impact in each social category. The results show that China is the country with the highest social impacts for all social categories. Despite China represents 88% of total production costs, the social impacts there encompass between 94% and 95% of the total laser printer impacts depending on the social category assessed. This reveals that social risk levels in the Chinese productive sectors supplying LEXMARK are high, so they can be identified as social hotspots of the laser printer. LEXMARK could therefore investigate opportunities and measures there to apply social improvements, not only at its production factory in China but also collaborating with its Chinese suppliers. This could result in a decrease of the social footprint of the laser printer.

Table 28. Social impacts of the Reference MLP by country.

Economic sector	Labour Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
China	13.034,71	18.259,07	9.280,80	22.796,66	7.598,67
USA	208,00	261,09	163,94	216,73	116,94
Japan	57,44	45,81	41,37	61,69	29,42
Germany	1,75	3,04	1,52	2,56	1,05
Philippines	252,92	538,06	325,11	704,97	234,70
South Korea	92,43	165,54	55,20	110,94	38,84
Thailand	47,56	47,38	48,58	80,59	32,40
Singapore	1,36	1,15	0,98	1,70	0,89
TOTAL	**13.696,17**	**19.321,16**	**9.917,50**	**23.975,84**	**8.052,91**

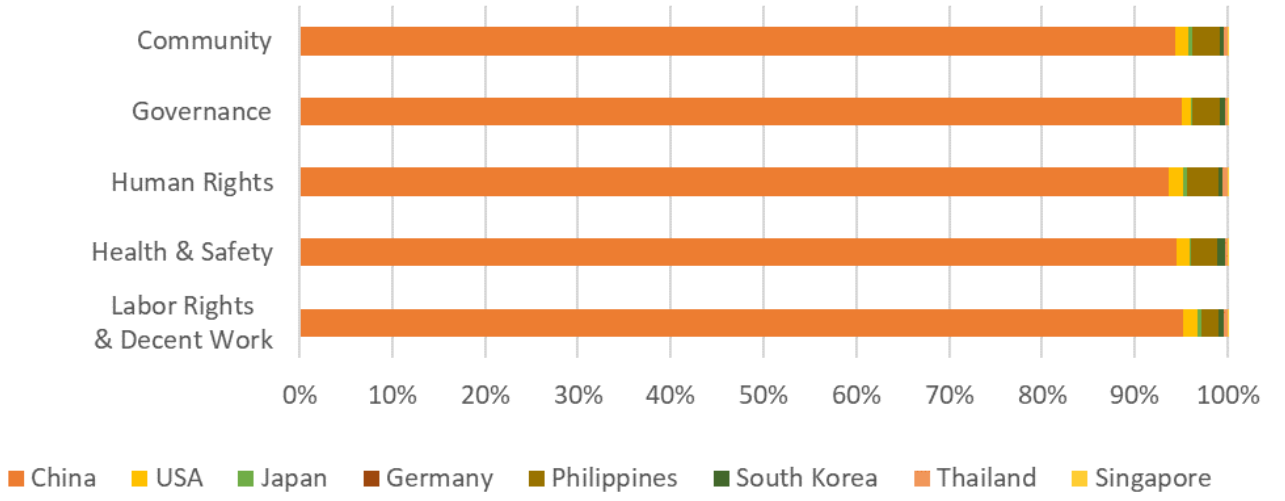

Figure 21. Contribution of each country to the total social impacts of the Reference MLP by social category.

5.3 CSERVEES MLP social life cycle assessment

5.3.1 Redesign changes

Redesign changes implemented in the LCSA as described in Table 22 are detailed in Table 29. Selected strategy in C-SERVEES PRINTER set is reusing part of the components for remanufacturing new printers.

Table 29. C-SERVEES MLP changes implemented in LCSA.

	Reference	**CSERVEES**	
Lifetime, years	5	5	
Functional units, printed pages	390000	390000	
Recycled content	Recycled plastics	Recycled plastics	
		BoM Part Number(s)	**Percentage of time replaced**
Remanufacturing	NO	17X7101	20%
		21K1191	30%
		21K2829	35%
		21K2809	35%
		21K2806	25%
		21K2830	35%
		21K1600, 21K1624, 21K2196	40%
		21K1520	35%
		21K2951	35%
		21K2975	35%
		21K2936	30%
		21K2969	35%
		21K2956	30%
		21K2801, 21K2988	60%
		21K2953	40%
		21K2952	40%
		21K2961	40%
		21K2967	40%
		21K2966	40%
		21K2965	40%
		21K2868, 21K2869	5%
		25B9160	10%
		21K8568	25%
		21K9000	10%
		21K8801	50%
		21K8804	50%
		21K8201	55%
		21K8021	20%
		3079274	45%
		21K8567	50%
		21K4211	45%

5.3.2 Social life cycle inventory

Primary data provided by LEXMARK was used as the starting point to carry out the S-LCA. Specifically, it provided economic data describing the supply chain composition and location, identifying all the economic costs required to produce the laser printer and the cost breakdown by countries and economic sectors. LEXMARK provided primary data for a series of components that account all together for 95 kg. The social impacts were extrapolated to China, for each economic sector, taking into account their respective weights in the laser printer. Table 30 shows the percentage breakdown of total production costs by countries and sectors.

Table 30. Production cost breakdown for the C-SERVEES MLP by countries and economic sectors.

Country/Sector	Plastic products	Ferrous metals	Non-FE metals	Paper products	Mineral products	Electronic equipment	Manufacturing process
TOTAL	20.89%	17.08%	1.64%	0.19%	1.97%	30.16%	28.06%
China	18.86%	16.81%	1.64%	0.19%	1.25%	21.54%	23.10%
USA	0.06%	0.01%				4.30%	
Japan	1.93%					0.52%	
Germany		0.09%				0.01%	
Philippines						2.11%	
South Korea					0.72%	1.43%	
Thailand		0.16%				0.25%	
Singapore	0.04%						
Mexico							4.96%

The sectors included in the assessment comprise those related to every material and/or component required to produce the laser printer, as well as the sector linked to the manufacturing process at LEXMARK facilities (i.e., electronic equipment sector in China). Electronic equipment is the most complex sector in the supply chain since the related components come from 7 different countries, being China the country where more money is spent in electronic components. By countries, China is by far the most important in the acquisition of materials and components, representing around 83% of total production costs for the laser printer. It is followed by Mexico and USA, although their contribution are much more limited with about 5% and 4.4%, respectively, of total production costs.

The SHDB method and datasets were then used to calculate the social impacts for each sector in each country (as explained in Section 3 of the main document). The Social Hotspot 2019 Category Method with Weights (which is available for SimaPro software) was used. The social impacts derived from the laser printer were obtained by allocating the production costs (in USD) to the corresponding social LCI datasets for every country-specific sector involved in the laser printer supply chain. The social LCI datasets used are listed in Table 31.

Table 31. Social LCI datasets for the country-specific sectors linked to the C-SERVEES laser printer.

Social Hotspot Database (SHDB)	Reference Unit
Chemical, rubber, plastic products/CHN S	USD
Chemical, rubber, plastic products/USA S	USD
Chemical, rubber, plastic products/JPN S	USD
Chemical, rubber, plastic products/SGP S	USD
Electronic equipment/CHN S China	USD
Electronic equipment/USA S	USD
Electronic equipment/JPN S Japan	USD
Electronic equipment/DEU S Germany	USD
Electronic equipment/PHL S	USD
Electronic equipment/KOR S SouthKorea	USD
Electronic equipment/THA S Thailand	USD
Ferrous metals/CHN S China	USD
Ferrous metals/USA S	USD

Social Hotspot Database (SHDB)	Reference Unit
Ferrous metals/DEU S Germany	USD
Ferrous metals/THA S	USD
Metals nec/CHN S China	USD
Paper products, publishing/CHN S China	USD
Mineral products nec/CHN S China	USD
Mineral products nec/KOR S	USD
Manufactures nec/CHN S	USD
Manufactures nec/MEX U	USD

5.3.3 Social life cycle impact assessment

The social footprint of the laser printer was calculated by aggregating the social impacts associated with each country-specific sector listed in Table 31 into a single social impacts indicator, namely the so-called Social Hotspot Index (SHI). Table 32 shows the SHI obtained for the laser printer, as well as its breakdown into the different social impact categories that contribute to the total social footprint.

Table 32. SHDB - Social Hotspot 2019 Category Method w Weights for C-SERVEES MLP.

Social category	Total impact (Pt)
Labour Rights & Decent Work	13,477.73
Health & Safety	19,149.11
Human Rights	9,706.25
Governance	24,125.27
Community	7,894.90
TOTAL: SHI	**74,353.25**

Figure 22 shows graphically the contribution of each social impact category to the total social footprint of the laser printer. It can be found that the greatest social impacts are due to Governance and Health & Safety issues, while social impacts affecting Community have the lowest contribution.

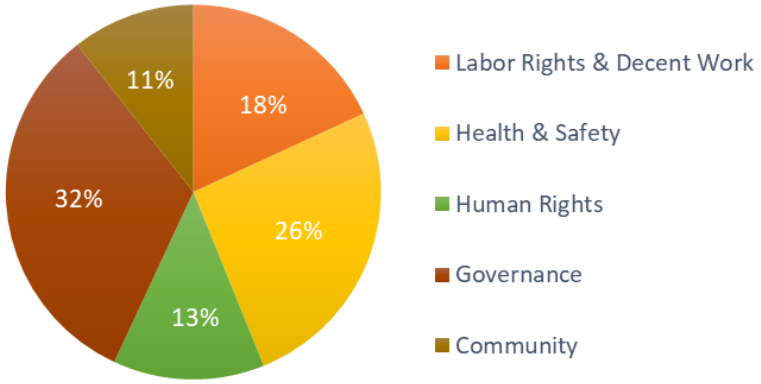

Figure 22. Percentage of impact categories in the social life cycle assessment for the C-SERVEES MLP.

Social impacts by economic sectors

Figure 23 shows the economic share of each productive sector in the laser printer supply chain. The economic sector with the highest contribution (i.e., that in which the company spent more money to produce the laser printer) is the electronic equipment sector, followed by the EEE manufacturing process and the sectors related to plastic products and ferrous metals. In contrast, paper products and non-ferrous metals are the economic sectors where expenditures are the lowest.

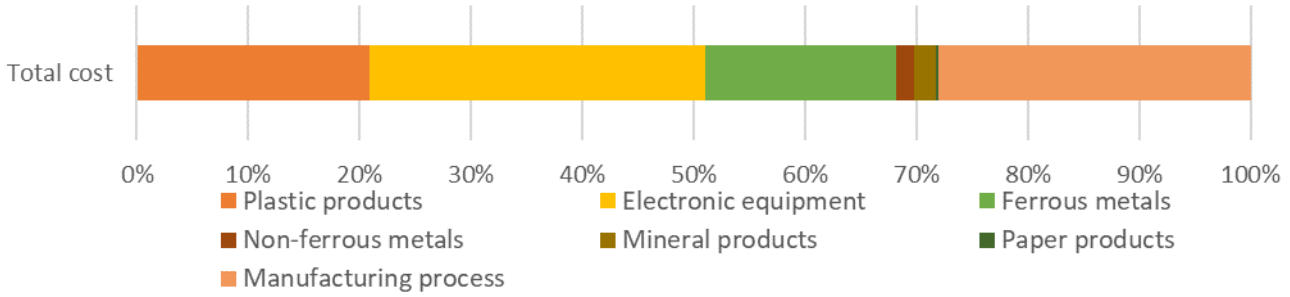

Figure 23. Production cost breakdown for the C-SERVEES MLP by economic sectors.

The social impacts were assessed for every economic sector. Table 33 shows the impacts for each social category obtained for each sector involved in the laser printer supply chain, while Figure 24 shows graphically the contribution by each sector to the total impact in each social category.

The results show that the manufacturing process used to produce the laser printer comprises most of the impact for every social category, ranging between 32% and 34% of total social impacts depending on the social category assessed. The impact contribution of the manufacturing process is therefore slightly higher than its economic share in total production costs, which is around 28%. This means that the laser printer manufacturing process, which takes place in China, except remanufacturing that takes place in Mexico, constitutes a social hotspot to be prioritised when planning measures to improve social conditions and reduce the social footprint of the laser printer.

There are other economic sectors showing relevant contributions to total social impacts, such as electronic equipment (25-28% contribution to total impacts), plastic products (21-22%) and ferrous metals (16-17%). The impact contributions of these sectors are completely aligned to their respective economic shares in total production costs, so their social risk levels are tolerable (i.e., social improvements could be applied there due to their large contribution to social impacts, but the priority is lower).

Mineral products, non-ferrous metals and paper products have negligible social impacts when compared to the other economic sectors composing the laser printer supply chain.

Table 33. Social impacts of the C-SERVEES MLP by economic sectors.

Economic sector	Labour Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
Plastic products	2,842.35	3,983.95	2,067.43	5,022.65	1,708.93
Electronic equipment	3,740.40	5,025.66	2,562.90	6,040.52	1,961.42
Ferrous metals	2,139.00	3,158.20	1,679.71	4,058.55	1,348.20
Non-ferrous metals	208.81	300.49	161.24	384.80	130.69
Mineral products	208.52	314.44	144.50	354.57	112.86
Paper products	32.12	46.26	22.78	56.98	18.76
Manufacturing	4,306.53	6,320.12	3,067.68	8,207.20	2,614.04
TOTAL	**13,477.73**	**19,149.11**	**9,706.25**	**24,125.27**	**7,894.90**

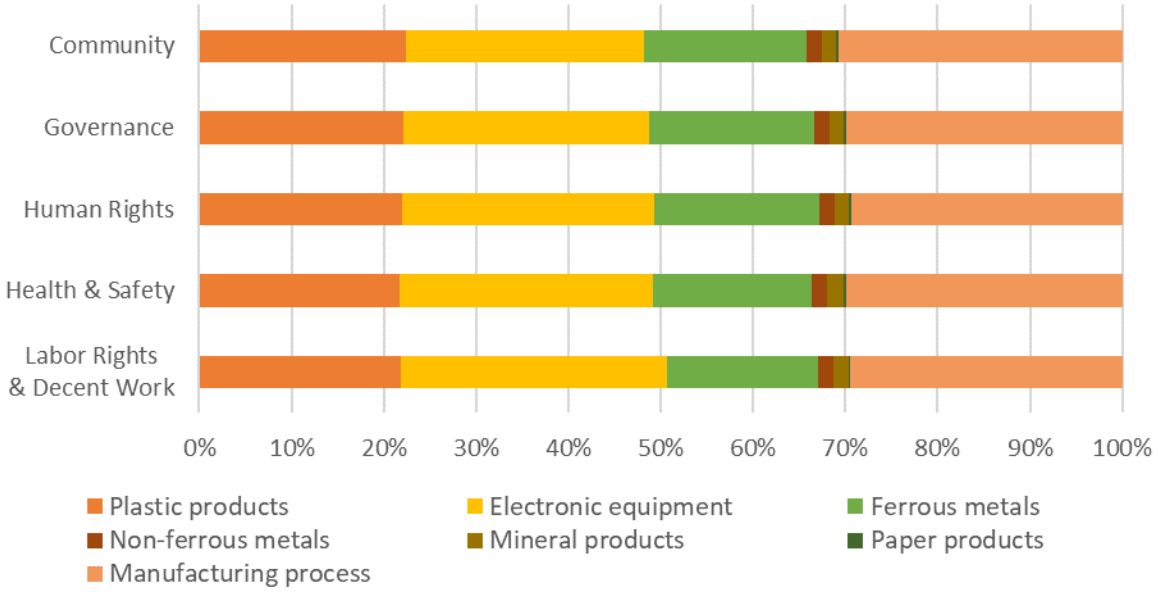

Figure 24. Contribution of each economic sector to the total social impacts of the C-SERVEES MLP by social category.

Social impacts by countries

Figure 25 shows the economic share of each country in the laser printer supply chain. The country with the highest contribution is China, comprising about 83% of the total laser printer production costs. It includes both the manufacturing costs at LEXMARK facilities and also the purchasing costs of various materials and components (especially plastic products, ferrous metals and electronic components) from other companies located in China as well. The expenditure in the rest of countries involved in the supply chain is very low in comparison. Nonetheless, the contribution to total production costs of some countries is still relevant, such as Mexico, where printers are remanufactured (5%), USA (4.4%), Japan (2.5%), Philippines (2.1%) and South Korea (2.1%), whereas the contribution of other countries is negligible.

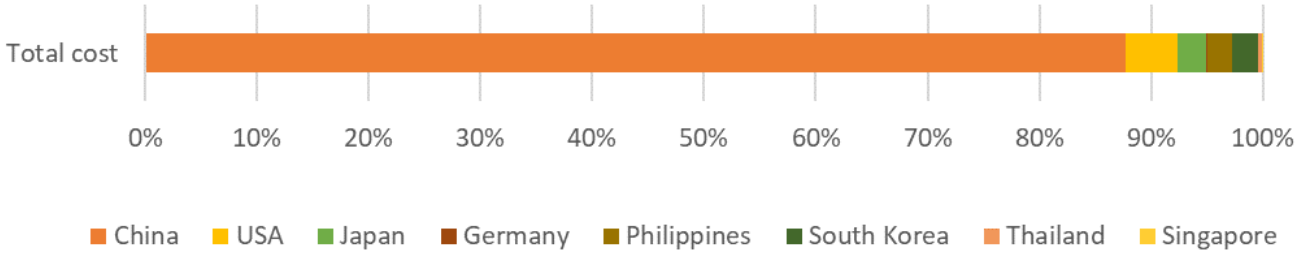

Figure 25. Production cost breakdown for the C-SERVEES MLP by country.

The social impacts were also assessed for every country in the laser printer supply chain. Table 34 shows the impacts for each social category obtained for each country, while Figure 26 shows graphically the contribution by each country to the total impact in each social category. The results show that China is the country with the highest social impacts for all social categories. Despite China represents 83% of total production costs, the social impacts there encompass between 89% and 92% of the total laser printer impacts depending on the social category assessed. This reveals that social risk levels in the Chinese productive sectors supplying LEXMARK are high, so they can be identified as social hotspots of the laser printer. LEXMARK could therefore investigate opportunities and measures there to apply social improvements, not only at its production factory in China but also collaborating with its Chinese suppliers. This could result in a decrease of the social footprint of the laser printer.

Table 34. Social impacts of the C-SERVEES MLP by country.

Economic sector	Labour Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
China	12,334.18	17,256.78	8,760.66	21,527.57	7,171.55
USA	208.00	261.09	163.94	216.73	116.94
Japan	57.44	45.81	41.37	61.69	29.42
Germany	1.75	3.04	1.52	2.56	1.05
Philippines	252.92	538.06	325.11	704.97	234.70
South Korea	92.43	165.54	55.20	110.94	38.84
Thailand	47.56	47.38	48.58	80.59	32.40
Singapore	1.36	1.15	0.98	1.70	0.89
Mexico	482.09	830.25	308.89	1,418.52	269.11
TOTAL	**13,477.73**	**19,149.11**	**9,706.25**	**24,125.27**	**7,894.90**

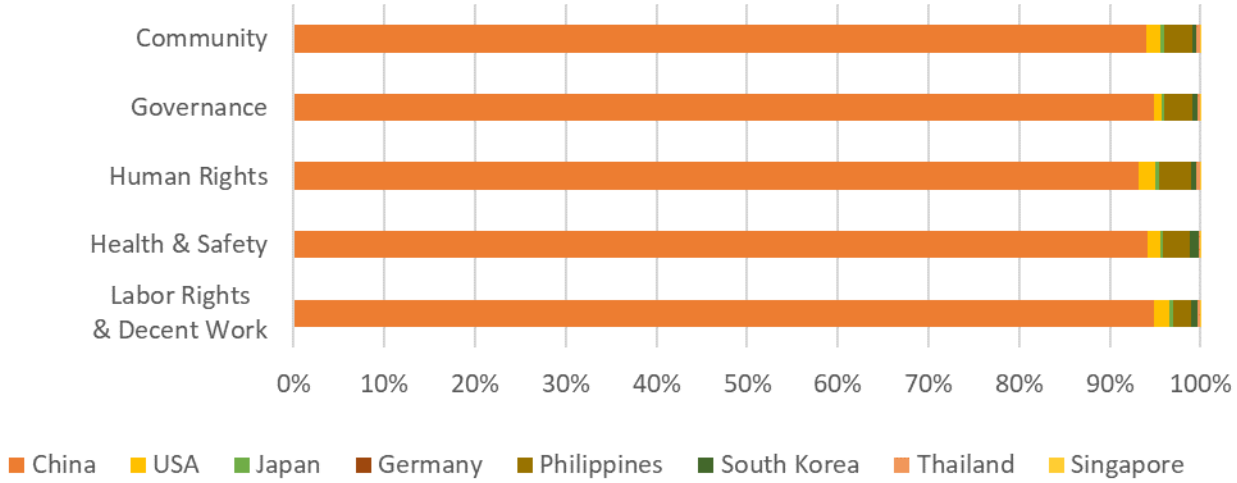

Figure 26. Contribution of each country to the total social impacts of the C-SERVEES MLP by social category.

5.4 MLP Comparative social life cycle assessment

Circularity enhancement of the C-SERVEES MLP is performed with the same cost amount although with different cost breakdown than the linear Reference MLP. Table 35 and Figure 27 show the social impact of the reference and the CSERVEES products for 1,000 printed pages. Reducing production costs in China by 5% shifted to remanufacturing in Mexico resulted in a decrease in social impacts by 0.8% on average, although with differences between -0.6% and 2% between different impact categories.

Table 35. Laser printers comparative S-LCA for 1,000 printed pages.

Units: Pts	Reference	C-SERVEES	Relative reduction
Labor Rights & Decent Work	35.12	34.56	1.6%
Health & Safety	49.54	49.10	0.9%
Human Rights	25.43	24.89	2.1%
Governance	61.48	61.86	-0.6%
Community	20.65	20.24	2.0%
Total	192.21	190.65	0.8%

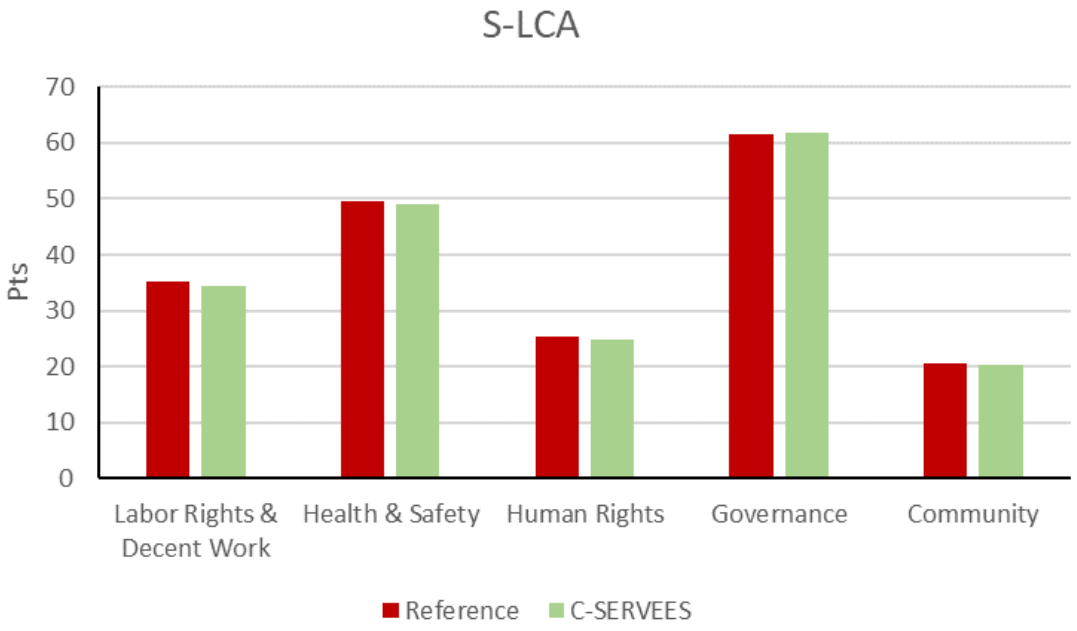

Figure 27. Laser printers comparative S-LCA.

6 Telecom equipment

The telecommunications equipment selected by ADVA for demonstration belongs to their ALM line (Advanced Link Monitoring) for optical networks, which is a relatively new and still upraising product line. It splits into an (electrically) active unit and passive sensors for fibre monitoring tasks like real-time information on fibre integrity, fast and easy localization of user traffic and remote active fire detection in sites accessed with a fibre. The novelty in the ALM product line makes it suitable for the demonstration purposes since it makes it simpler to introduce changes on the product line. Two variants of the active ALM units were considered for the demonstration, namely 16ALM and 64ALM. In addition, two different configurations were considered for the passive sensors. The ALM product selected as the reference for the life cycle sustainability assessment was the ADVA 16ALM/#1650D/AC, while one sensor configuration for door-opening detection was included in the assessment. More details on the current ALM product selected for the sustainability assessment are shown in Table 36.

The functional unit considered in the present study is one hour of one ALM product monitoring, including the active unit (ADVA 16ALM/#1650D/AC) and 50 passive sensors. This combined system offers continuous monitoring throughout its 8-year lifetime (i.e., 365 days/year and 24 h/day) in the Reference version. The assessment was initially performed for one product and at the end converted to the functional unit.

Table 36. Technical specifications of the demo telecom product.

MODEL	**ADVA 16ALM/#1650D/AC**
Image	
Product number	1043709841-02
Description	Advanced Link Monitor (ALM), 16 ports with LC/APC connectors, AC powered
Colour	Grey
Size	44 × 215 × 213 mm
Weight / Packaged weight	< 2 kg / 11.6 kg
Power typical / maximum	10 W / 13 W
Country of origin	Germany

The activities conducted in the LCSA were derived from the ALM-CIRCMODE short-term actions validated in WP2. The table below presents the ALM-CIRCMODE canvas sub-components and their validated short-term CE actions, as presented in Table 24 in D2.4, and the selected strategies implemented in WP5 as C-SERVEES product.

Table 37. Validated short-term ALM-CIRCMODE Canvas Key Circular sub-components and their associated Circular Economy Actions relevant for the LCSA.

ALM-CIRCMODE Canvas Sub-Component	**ALM-CIRCMODE validated short-term Circular Economy Actions**	**LCSA implemented**
ALM_C1.1 Diversifying circular activities	ALM_A1.1.1 Design for longevity, in particular better maintainability	Lifetime from 8 to 15 years
ALM_C1.2 Embrace eco-design to ensure products circularity across life-cycle stages	ALM_A1.2.2 Devise an eco-design approach in production and Design for Recycling	Recycled passive sensors
ALM-C9.2: Introducing and/or enhancing manufacturing and sales processes to account for	ALM_A9.2.1 Reduce costs of manual disassembly for recycling	10% reuse in central unit

ALM-CIRCMODE Canvas Sub-Component	ALM-CIRCMODE validated short-term Circular Economy Actions	LCSA implemented
costs associated with the end-of life and second life of materials, components and products		

6.1 Functional unit and system boundaries

The product function for the ALM product is fibre monitoring. The product considered in the study is one ALM product, including the active unit (ADVA 16ALM/#1650D/AC) and 50 passive sensors, which offers continuous monitoring throughout its 8-year lifetime for the Reference Product (i.e., 365 days/year and 24 h/day) and 15-year lifetime for the C-SERVEES Product. The functional unit for the comparative assessment is 1 hour of monitoring network.

Table 38 shows the system boundaries considered for the ALM product, identifying the life cycle phases, processes and other elementary flows included and excluded in the study.

Table 38.System boundaries considered for the Telecom equipment.

Life cycle phase	Included	Excluded
Raw material extraction and processing	Extraction of natural resources Refining and raw material production Intermediate product manufacturing Waste treatment and transport	Infrastructure
Product manufacturing	Energy for product manufacturing/assembly Transport	Infrastructure Production losses Packaging

6.2 Reference TE social life cycle assessment

6.2.1 Social life cycle inventory

Primary data provided by ADVA was used as the starting point to carry out the S-LCA. Specifically, it provided economic data describing the supply chain composition and location, identifying all the economic costs required to produce the ALM product and the cost breakdown by countries and economic sectors. Table 39 shows the percentage breakdown of total production costs by countries and sectors.

Table 39. Production cost breakdown for the Reference TE by countries and economic sectors.

Country/Sector	Plastic products	Ferrous metals	Non- Fe metals	Paper products	Mineral products	Electronic equipment	Manufacturing process
TOTAL	0.253%	1.424%	4.432%	0.038%	54.228%	11.113%	28.513%
Germany	0.052%	0.268%	3.992%	0.032%	2.560%	4.061%	28.513%
Japan		0.036%	0.112%		19.365%		
China		0.931%	0.328%	0.004%	19.948%	1.251%	
Hong Kong		0.173%			0.000%		
USA		0.000%		0.002%	12.354%	5.258%	
UK	0.187%	0.004%				0.094%	
Taiwan	0.014%					0.364%	
Switzerland		0.012%				0.027%	
South Korea						0.006%	
Singapore						0.001%	
Thailand						0.001%	
The Netherlands						0.050%	

The sectors included in the assessment comprise those related to every material and/or component required to produce the ALM product, as well as the sector linked to the manufacturing process at ADVA facilities (i.e., electronic equipment sector in Germany). Electronic equipment is the most complex sector in the supply chain since the related components come from 11 different countries, being USA and Germany those where more money is spent in electronic components. By countries, Germany, Japan, China and USA are the most important in the acquisition of materials and components. It would be advisable to check the actual origin of some minerals, which may be different from the countries where mineral products are purchased.

The SHDB method and datasets were then used to calculate the social impacts for each sector in each country (as explained in Section 3 of the main document). The Social Hotspot 2019 Category Method with Weights (which is available for SimaPro software) was used. The social impacts derived from the ALM product were obtained by allocating the production costs (in USD) to the corresponding social LCI datasets for every country-specific sector involved in the ALM product supply chain. The social LCI datasets used are listed in Table 40.

Table 40. Social LCI datasets for the country-specific sectors linked to the Reference TE.

Social Hotspot Database (SHDB)	Reference Unit
Chemical, rubber, plastic products/DEU S_Germany	USD
Chemical, rubber, plastic products/GBR S_UK	USD
Chemical, rubber, plastic products/TWN S	USD
Chemical, rubber, plastic products/USA S	USD
Electronic equipment/CHE S_Switzerland	USD
Electronic equipment/CHN S_China	USD
Electronic equipment/DEU S_Germany	USD
Electronic equipment/GBR S_UK	USD
Electronic equipment/JPN S_Japan	USD
Electronic equipment/KOR S_SouthKorea	USD
Electronic equipment/NLD S_Netherlands	USD
Electronic equipment/SGP S_Singapore	USD
Electronic equipment/THA S_Thailand	USD
Electronic equipment/TWN S	USD
Electronic equipment/USA S	USD
Ferrous metals/CHE S_Switzerland	USD
Ferrous metals/CHN S_China	USD
Ferrous metals/DEU S_Germany	USD
Ferrous metals/GBR S_UK	USD
Ferrous metals/HKG S_HongKong	USD
Ferrous metals/JPN S_Japan	USD
Metals nec/CHN S_China	USD
Metals nec/JPN S_Japan	USD
Mineral products nec/CHN S	USD
Mineral products nec/DEU S	USD
Mineral products nec/JPN S	USD
Mineral products nec/USA S	USD
Paper products, publishing/CHN S	USD
Paper products, publishing/DEU S	USD
Paper products, publishing/USA S	USD

6.2.2 Social life cycle impact assessment

The social footprint of the ALM product was calculated by aggregating the social impacts associated with each country-specific sector listed in Table 40 into a single social impacts indicator, namely the so-called Social Hotspot Index (SHI). Table 41 shows the SHI obtained for the ALM product, as well as its breakdown into the different social impact categories that contribute to the total social footprint.

Table 41. Social impacts of the Reference TE by impact category.

Social category	Total impact (Pt)
Labour Rights & Decent Work	9,793.61
Health & Safety	16,396.41
Human Rights	7,622.81
Governance	13,209.98
Community	5,148.97
TOTAL: SHI	52,171.77

Figure 28 shows graphically the contribution of each social impact category to the total social footprint of the ALM product. It can be found that the greatest social impacts are due to Governance and Health & Safety issues, while social impacts affecting Community have the lowest contribution.

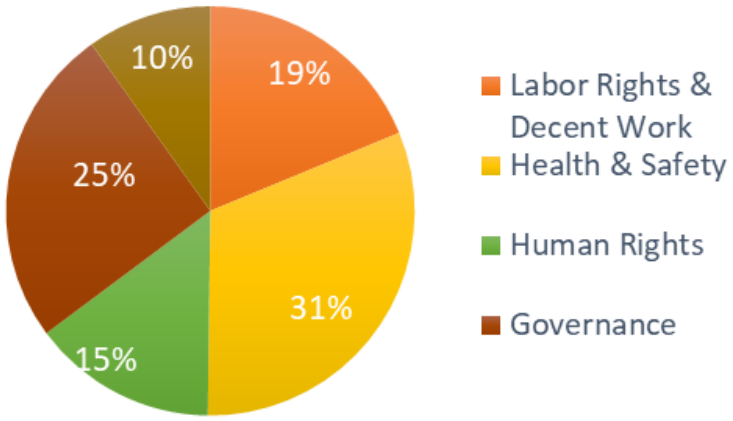

Figure 28. Percentage of impact categories in the social life cycle assessment for the Reference TE.

Social impacts by economic sectors

Figure 29 shows the economic share of each productive sector in the ALM product supply chain. The economic sector with the highest contribution (i.e., that in which the company spent more money to produce the ALM product) is the non-ferrous metals by the use of aluminium in the passive sensors, followed by the EEE manufacturing process (performed in ADVA facilities) and the mineral sector for the optical fibre. In contrast, paper and plastic products and ferrous metals are the economic sectors where expenditures are the lowest.

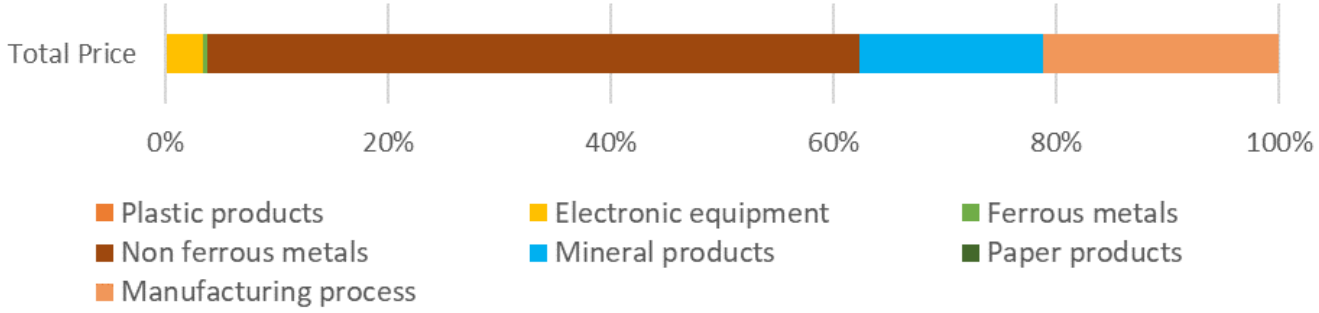

Figure 29. Production cost breakdown for the Reference TE by economic sectors.

The social impacts were assessed for every economic sector. Table 42 shows the impacts for each social category obtained for each sector involved in the ALM product supply chain, while Figure 30 shows graphically the contribution by each sector to the total impact in each social category. The results show that the mineral

products together with non-ferrous metals used in the ALM product comprises most of the impact for every social category (with over 70% of total impacts). The social impacts of the manufacturing process conducted in ADVA facilities (Germany) also have a relevant contribution, which ranges between 12% and 17% depending on the social category. However, it should be noted that the impact contribution of the manufacturing process is low compared to the economic share that it has in total production costs, which is around 21%. The reason is that social risk levels in the electronic equipment sector in Germany are lower than those in many other sectors and countries where ADVA is purchasing the materials and components. Plastic and paper products have negligible social impacts when compared to the other economic sectors composing the ALM product supply chain.

Table 42. Social impacts of the Reference TE by economic sectors.

Economic sector	Labour Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
Plastic products	5.46	7.30	4.14	6.91	4.06
Electronic equipment	603.10	819.40	445.83	765.95	315.00
Ferrous metals	147.30	218.78	109.57	261.30	87.80
Non-ferrous metals	3,572.90	6,830.85	2,908.59	4,216.65	1,743.90
Mineral products	4,067.39	5,657.57	2,956.25	6,325.22	2,259.01
Paper products	1.19	2.08	0.93	1.73	0.65
Manufacturing	1,396.28	2,860.43	1,197.50	1,632.22	738.54
TOTAL	**9,793.61**	**16,396.41**	**7,622.81**	**13,209.98**	**5,148.97**

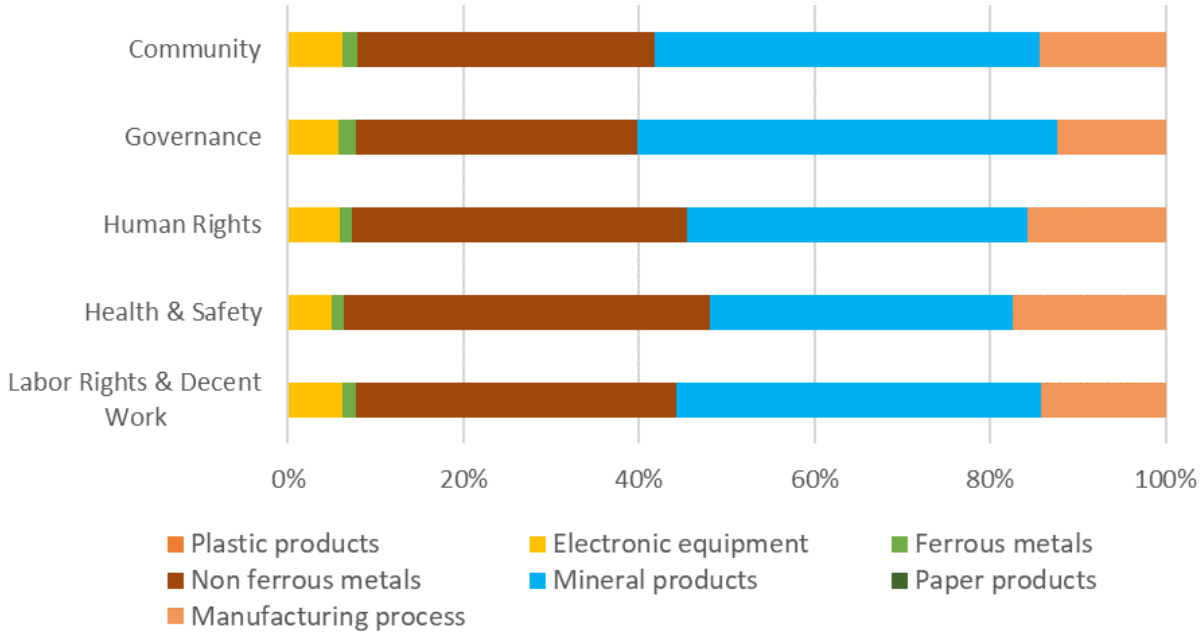

Figure 30. Contribution of each economic sector to the total social impacts of the Reference TE by social category.

Social impacts by countries

Figure 31 shows the economic share of each country in the ALM product supply chain. The country with the highest contribution is Germany, comprising about 82% of the total ALM production costs. It includes both the manufacturing costs at ADVA facilities and the purchasing costs of various materials and components (plastic and paper products, ferrous metals, mineral products and electronic components) from other companies located in Germany as well. Other countries with relevant contributions are China (6.5%), Japan (6%), and USA (5%), whereas the expenditure in the rest of countries is very low in comparison.

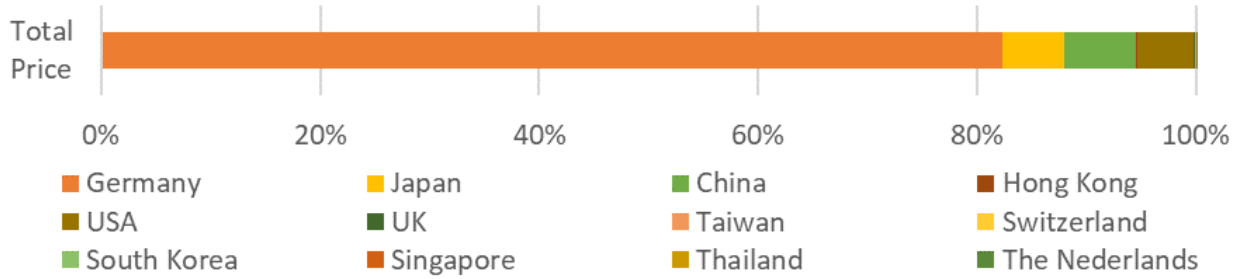

Figure 31. Production cost breakdown for the Reference TE by country.

The social impacts were also assessed for every country in the TE supply chain. Table 43 shows the impacts for each social category obtained for each country, while Figure 32 shows graphically the contribution by each country to the total impact in each social category. The results show that Germany and China are the countries with the highest social impacts for all social categories. Despite China represents only 6.5% of total production costs associated with the ALM product, the social impacts there encompass between 30% and 47% of the total ALM product impacts depending on the social category assessed. This reveals that social risk levels in the Chinese productive sectors supplying ADVA are high, so they can be identified as social hotspots of the ALM product. ADVA could therefore investigate opportunities and measures together its Chinese suppliers to apply social improvements there, which could in turn derive in a decrease of the social footprint of the ALM product. Oppositely, the case of Germany is positively remarkable since it covers 82% of total ALM production costs, including both product manufacturing and supplies purchased there, but it only causes between 45% and 61% of total social impacts.

Table 43. Social impacts of the Reference TE by country.

Economic sector	Labour Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
Germany	5,113.52	9,964.31	4,222.20	6,003.11	2,551.14
Japan	358.88	254.85	244.73	306.04	148.64
China	3,521.51	5,031.49	2,505.53	6,264.24	1,986.80
Hong Kong	13.85	20.40	4.67	10.62	3.80
USA	758.36	1,095.11	621.45	590.29	443.40
UK	6.37	9.41	4.22	7.93	4.74
Taiwan	18.00	16.40	17.42	23.40	8.27
Switzerland	1.23	1.50	1.08	1.84	1.07
South Korea	0.28	0.48	0.17	0.35	0.12
Singapore	0.05	0.05	0.03	0.07	0.03
Thailand	0.17	0.18	0.17	0.29	0.11
The Netherlands	1.39	2.21	1.12	1.80	0.83
TOTAL	**9,793.61**	**16,396.41**	**7,622.81**	**13,209.98**	**5,148.97**

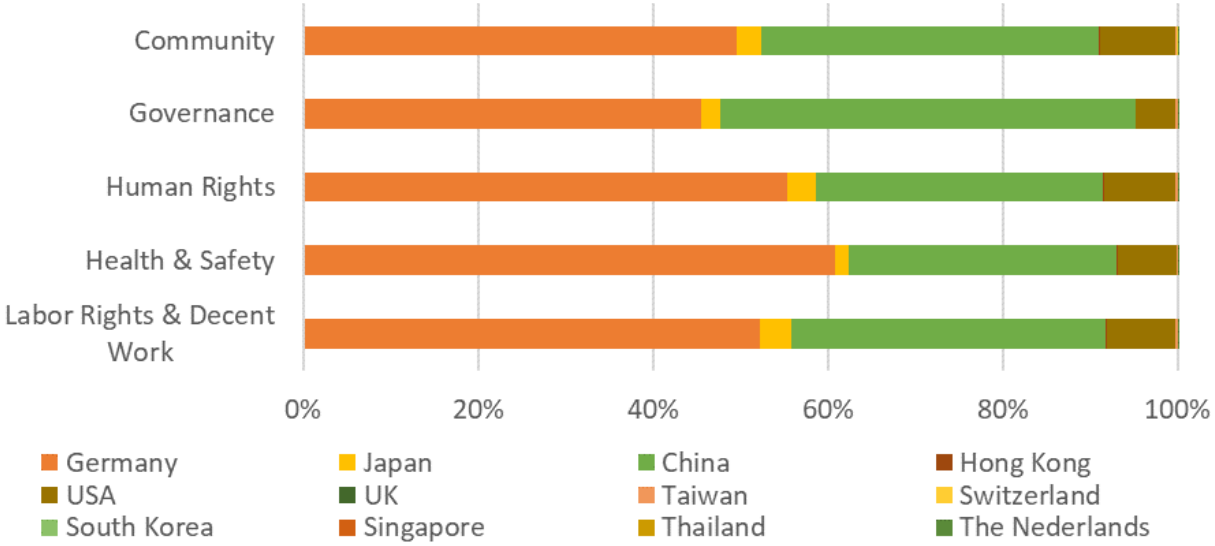

Figure 32. Contribution of each country to the total social impacts of the Reference TE by social category.

6.3 CSERVEES TE social life cycle assessment

6.3.1 Redesign changes

Redesign changes implemented in the LCSA as described in Table 14 are detailed in Table 44. The inclusion of ICT improves maintenance monitoring and allows for a longer service life of 8 to 15 years and the 10 % reuse of the components for the central ALM unit. Circularity is also improved with the use of secondary aluminium for passive sensors.

Table 44. C-SERVEES TE redesign changes.

	Reference	C-SERVEES
Lifetime, years	8	15
Functional units, hours	70080	131400
Passive units	50	50
Recycled content	No recycled materials	Passive units with secondary aluminum
Remanufacturing	No	10% reuse in central active unit

6.3.2 Social life cycle inventory

Primary data provided by ADVA was used as the starting point to carry out the S-LCA. Specifically, it provided economic data describing the supply chain composition and location, identifying all the economic costs required to produce the ALM product and the cost breakdown by countries and economic sectors. Table 45 shows the percentage breakdown of total production costs by countries and sectors.

Table 45. Production cost breakdown for the C-SERVEES TE by countries and economic sectors.

Country/Sector	Plastic products	Ferrous metals	Non-Fe metals	Paper products	Mineral products	Electronic equipment	Manufacturing process
TOTAL	0.253%	1.425%	4.389%	0.038%	54.252%	11.118%	28.526%
Germany	0.052%	0.268%	3.949%	0.032%	2.561%	4.063%	28.526%
Japan		0.036%	0.112%		19.374%		
China		0.932%	0.328%	0.004%	19.957%	1.252%	
Hong Kong		0.173%			0.000%		

Country/Sector	Plastic products	Ferrous metals	Non-Fe metals	Paper products	Mineral products	Electronic equipment	Manufacturing process
USA		0.000%		0.002%	12.360%	5.260%	
UK	0.187%	0.004%				0.094%	
Taiwan	0.014%					0.364%	
Switzerland		0.012%				0.027%	
South Korea						0.006%	
Singapore						0.001%	
Thailand						0.001%	
The Netherlands						0.050%	

The sectors included in the assessment comprise those related to every material and/or component required to produce the ALM product, as well as the sector linked to the manufacturing process at ADVA facilities (i.e., electronic equipment sector in Germany). Electronic equipment is the most complex sector in the supply chain since the related components come from 11 different countries, being USA and Germany those where more money is spent in electronic components. By countries, Germany, Japan, China and USA are the most important in the acquisition of materials and components. It would be advisable to check the actual origin of some minerals, which may be different from the countries where mineral products are purchased.

The SHDB method and datasets were then used to calculate the social impacts for each sector in each country (as explained in Section 3 of the main document). The Social Hotspot 2019 Category Method with Weights (which is available for SimaPro software) was used. The social impacts derived from the ALM product were obtained by allocating the production costs (in USD) to the corresponding social LCI datasets for every country-specific sector involved in the ALM product supply chain. The social LCI datasets used are listed in Table 46.

Table 46. Social LCI datasets for the country-specific sectors linked to the C-SERVEES TE.

Social Hotspot Database (SHDB)	Reference Unit
Chemical, rubber, plastic products/DEU S_Germany	USD
Chemical, rubber, plastic products/GBR S_UK	USD
Chemical, rubber, plastic products/TWN S	USD
Chemical, rubber, plastic products/USA S	USD
Electronic equipment/CHE S_Switzerland	USD
Electronic equipment/CHN S_China	USD
Electronic equipment/DEU S_Germany	USD
Electronic equipment/GBR S_UK	USD
Electronic equipment/JPN S_Japan	USD
Electronic equipment/KOR S_SouthKorea	USD
Electronic equipment/NLD S_Netherlands	USD
Electronic equipment/SGP S_Singapore	USD
Electronic equipment/THA S_Thailand	USD
Electronic equipment/TWN S	USD
Electronic equipment/USA S	USD
Ferrous metals/CHE S_Switzerland	USD
Ferrous metals/CHN S_China	USD
Ferrous metals/DEU S_Germany	USD
Ferrous metals/GBR S_UK	USD
Ferrous metals/HKG S_HongKong	USD
Ferrous metals/JPN S_Japan	USD
Metals nec/CHN S_China	USD
Metals nec/JPN S_Japan	USD
Mineral products nec/CHN S	USD
Mineral products nec/DEU S	USD
Mineral products nec/JPN S	USD
Mineral products nec/USA S	USD
Paper products, publishing/CHN S	USD
Paper products, publishing/DEU S	USD

Social Hotspot Database (SHDB)	Reference Unit
Paper products, publishing/USA S	USD

6.3.3 Social life cycle impact assessment

The social footprint of the ALM product was calculated by aggregating the social impacts associated with each country-specific sector listed in Table 46 into a single social impacts indicator, namely the so-called Social Hotspot Index (SHI). Table 47 shows the SHI obtained for the ALM product, as well as its breakdown into the different social impact categories that contribute to the total social footprint.

Table 47. Social impacts of the C-ESERVEES TE by impact category.

Social category	Total impact (Pt)
Labour Rights & Decent Work	9,754.03
Health & Safety	16,320.46
Human Rights	7,590.57
Governance	13,163.63
Community	5,129.74
TOTAL: SHI	**51,958.44**

Figure 33 shows graphically the contribution of each social impact category to the total social footprint of the ALM product. It can be found that the greatest social impacts are due to Health & Safety and Governance issues, while social impacts affecting Community have the lowest contribution.

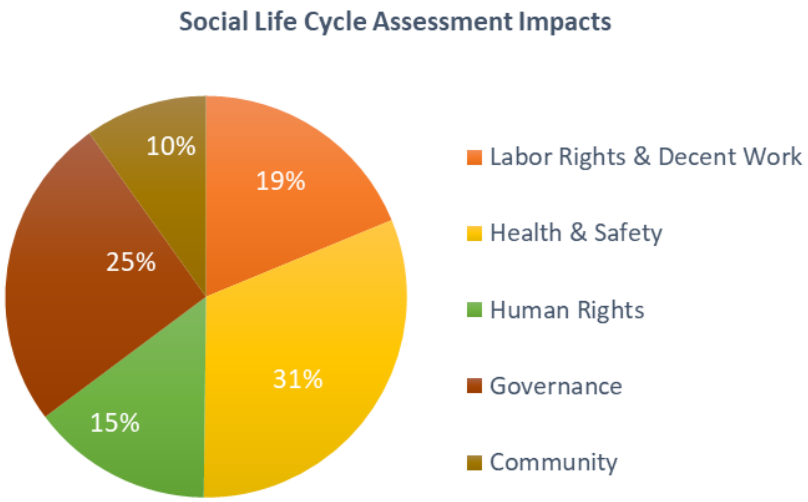

Figure 33. Percentage of impact categories in the social life cycle assessment for the C-SERVEES TE.

Social impacts by economic sectors

Figure 34 shows the economic share of each productive sector in the ALM product supply chain. The economic sector with the highest contribution (i.e., that in which the company spent more money to produce the ALM product) is the non-ferrous metals using aluminium in the passive sensors, followed by the EEE manufacturing process (performed in ADVA facilities) and the mineral sector for the optical fibre. In contrast, paper and plastic products and ferrous metals are the economic sectors where expenditures are the lowest.

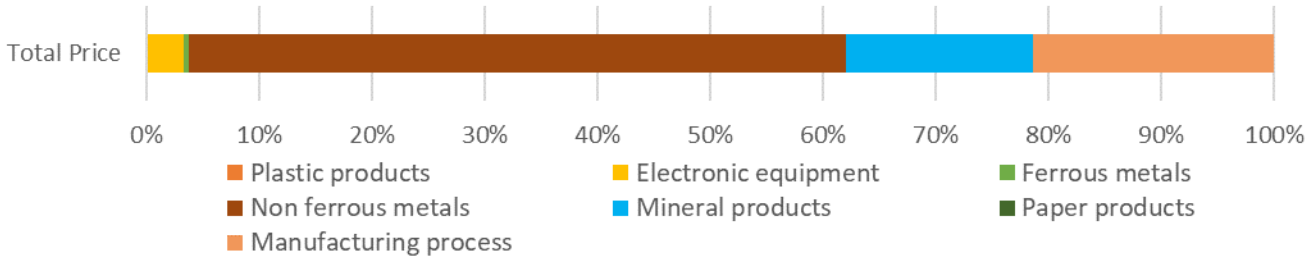

Figure 34. Production cost breakdown for the C-SERVEES TE by economic sectors.

The social impacts were assessed for every economic sector. The results show that the mineral products together with non-ferrous metals used in the ALM product comprises most of the impact for every social category (with over 70% of total impacts). The social impacts of the manufacturing process conducted in ADVA facilities (Germany) also have a relevant contribution, which ranges between 12% and 18% depending on the social category. However, it should be noted that the impact contribution of the manufacturing process is low compared to the economic share that it has in total production costs, which is around 21%. The reason is that social risk levels in the electronic equipment sector in Germany are lower than those in many other sectors and countries where ADVA is purchasing the materials and components. Plastic and paper products have negligible social impacts when compared to the other economic sectors composing the ALM product supply chain.

Table 48 shows the impacts for each social category obtained for each sector involved in the ALM product supply chain, while Figure 35 shows graphically the contribution by each sector to the total impact in each social category. The results show that the mineral products together with non-ferrous metals used in the ALM product comprises most of the impact for every social category (with over 70% of total impacts). The social impacts of the manufacturing process conducted in ADVA facilities (Germany) also have a relevant contribution, which ranges between 12% and 18% depending on the social category. However, it should be noted that the impact contribution of the manufacturing process is low compared to the economic share that it has in total production costs, which is around 21%. The reason is that social risk levels in the electronic equipment sector in Germany are lower than those in many other sectors and countries where ADVA is purchasing the materials and components. Plastic and paper products have negligible social impacts when compared to the other economic sectors composing the ALM product supply chain.

Table 48. Social impacts of the C-SERVEES TE by economic sectors.

Economic sector	Labour Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
Plastic products	5.46	7.30	4.14	6.91	4.06
Electronic equipment	603.10	819.40	445.83	765.95	315.00
Ferrous metals	147.30	218.78	109.57	261.30	87.80
Non-ferrous metals	3,533.33	6,754.91	2,876.35	4,170.30	1,724.67
Mineral products	4,067.39	5,657.57	2,956.25	6,325.22	2,259.01
Paper products	1.19	2.08	0.93	1.73	0.65
Manufacturing	1,396.28	2,860.43	1,197.50	1,632.22	738.54
TOTAL	**9,754.03**	**16,320.46**	**7,590.57**	**13,163.63**	**5,129.74**

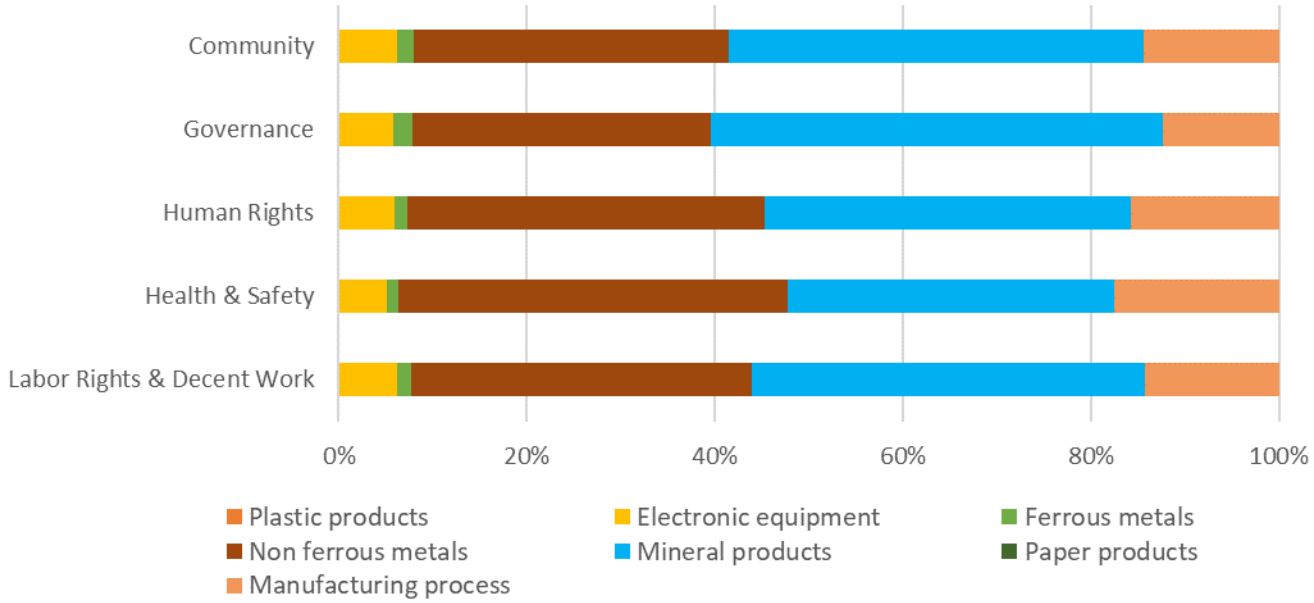

Figure 35. Contribution of each economic sector to the total social impacts of the C-SERVEES TE by social category.

Social impacts by countries

Figure 36 shows the economic share of each country in the ALM product supply chain. The country with the highest contribution is Germany, comprising about 82% of the total ALM production costs. It includes both the manufacturing costs at ADVA facilities and the purchasing costs of various materials and components (plastic and paper products, ferrous metals, mineral products and electronic components) from other companies located in Germany as well. Other countries with relevant contributions are China (6.6%), Japan (5.7%), and USA (5.2%), whereas the expenditure in the rest of countries is very low in comparison.

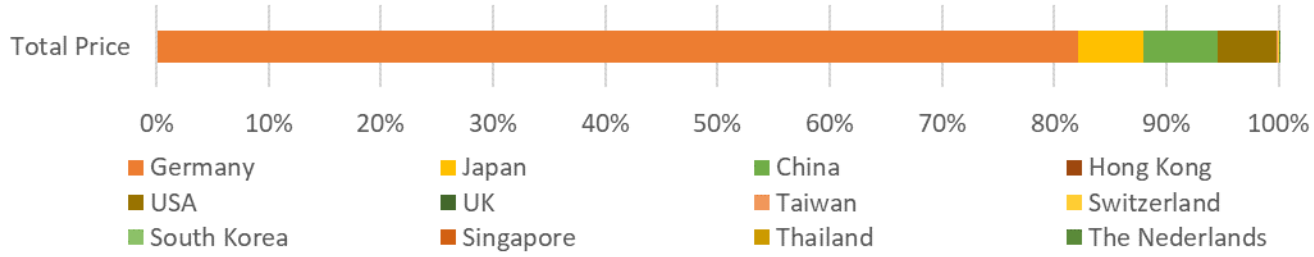

Figure 36. Production cost breakdown for the C-SERVEES TE by country.

The social impacts were also assessed for every country in the ALM product supply chain. Table 49 shows the impacts for each social category obtained for each country, while Figure 37 shows graphically the contribution by each country to the total impact in each social category. The results show that Germany and China are the countries with the highest social impacts for all social categories. Despite China represents only 6.6% of total production costs associated with the ALM product, the social impacts there encompass between 30% and 48% of the total ALM product impacts depending on the social category assessed. This reveals that social risk levels in the Chinese productive sectors supplying ADVA are high, so they can be identified as social hotspots of the ALM product. ADVA could therefore investigate opportunities and measures together its Chinese suppliers to apply social improvements there, which could in turn derive in a decrease of the social footprint of the ALM product. Oppositely, the case of Germany is positively remarkable since it covers 82% of total ALM production costs, including both product manufacturing and supplies purchased there, but it only causes between 45% and 61% of total social impacts.

Table 49. Social impacts of the C-SERVEES TE by country.

Economic sector	Labour Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
Germany	1,589.87	3,202.25	1,352.00	1,876.00	838.56
Japan	358.88	254.85	244.73	306.04	148.64
China	3,521.51	5,031.49	2,505.53	6,264.24	1,986.80
Hong Kong	13.85	20.40	4.67	10.62	3.80
USA	758.36	1,095.11	621.45	590.29	443.40
UK	6.37	9.41	4.22	7.93	4.74
Taiwan	18.00	16.40	17.42	23.40	8.27
Switzerland	1.23	1.50	1.08	1.84	1.07
South Korea	0.28	0.48	0.17	0.35	0.12
Singapore	0.05	0.05	0.03	0.07	0.03
Thailand	0.17	0.18	0.17	0.29	0.11
The Netherlands	1.39	2.21	1.12	1.80	0.83
TOTAL	**6,269,96**	**9,634,34**	**4,752,61**	**9,082,87**	**3,436,39**

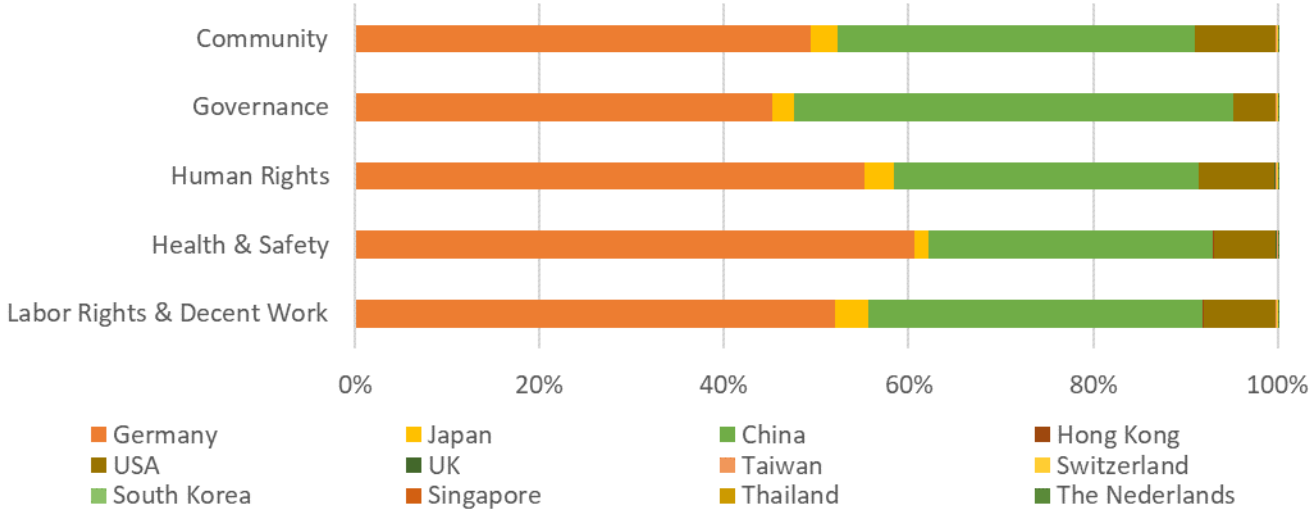

Figure 37. Contribution of each country to the total social impacts of the C-SERVEES TE by social category.

6.4 TE comparative social life cycle assessment

The improvement of the circularity of the C-SERVEES telecommunication equipment is done at a similar amount of cost to the linear Reference. The introduction of ICT has improved the maintenance of the TE increasing the lifetime from 8 to 15 years and making feasible the 10% reuse of the central ALM unit. Table 50 and Figure 38 show the social impact of the reference and the CSERVEES products for one functional unit. It can be clearly seen how the increase of the lifetime and reusing parts of the product's modules for remanufacturing reduces 47% the social impact of the production process.

Table 50. Social impact difference between Reference and C-SERVEES TE for 1 hour of monitoring network.

Units: Pts	Reference	CSERVEES	Relative reduction
Labor Rights & Decent Work	0.14	0.07	46.9%
Health & Safety	0.23	0.12	46.9%
Human Rights	0.11	0.06	46.9%
Governance	0.19	0.10	46.9%
Community	0.07	0.04	46.9%
Total	0.74	0.40	46.9%

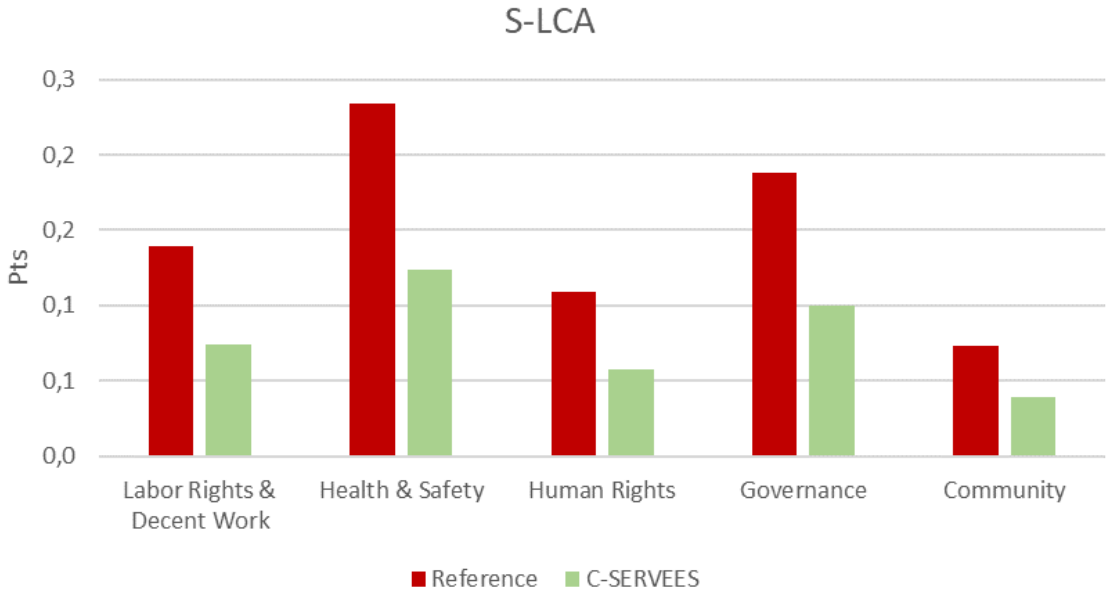

Figure 38. Social impact difference between Reference and C-SERVEES TE for 1 hour of monitoring network.

7 TV set

The TV set selected for demonstration is GRUNDIG G43C 891 5A, which is a 43” smart-TV model with energy efficiency class A^+ and connectivity features. This product is manufactured in Tekirdağ (Turkey) and currently on sale in Turkey and the EU. ARÇELIK selected this model because it has convenient size (43”) for hospitality customers targeted in the demonstration. The selected TV has enclosure and stand made of halogen-free plastics. More details on the current TV set selected for demonstration are shown in Table 51.

The functional unit considered in the present study is one watched hour of the 43” TV set GRUNDIG G43C 891 5A. The performance of this TV set is 10,784 hours of viewing during its 8-year lifetime (assuming an average use of 337 days/year and 4 h/day). The assessment was initially performed for one and at the end converted to the functional unit.

Table 51. Technical specifications of the demo TV set.

MODEL	**GRUNDIG G43C 891 5A**
Image	
Product (EAN) number	8690842398605
Description	43" / 108 cm, UHD (3.840 x 2.160), 50 Hz, HEVC/H.265, Smart
Colour	Black
Size	625 × 231 × 976 mm
Weight / Packaged weight	9.2 kg / 12.0 kg
Features	Picture features: Picture Noise Reduction, DLTI, DCTI, DNR, Digital Comb Filter (3D) Colour system: Multisystem USB supported files: .mp3, .m4a, .aac, .jpg, .jpe, .bmp, .png, .mov, .mpg, .mpe, .vob, .dat, .trp, .ts, .avi, .mp4, .mkv, .div
Energy class	A^+
Electricity consumption per year	53.3 kWh
Average power	0.15 W (Stand-by), 38.8 W (Nominal)
Country of origin	Turkey

The activities conducted in the LCSA were derived from the TV-CIRCMODE short-term actions validated in WP2. The table below presents the TV-CIRCMODE canvas sub-components and their validated short-term CE actions, as presented in Table 24 in D2.5, and the selected strategies implemented in WP5 as C-SERVEES product.

Table 52. Validated short-term TV-CIRCMODE Canvas Key Circular sub-components and their associated Circular Economy Actions relevant for the LCSA.

TV-CIRCMODE Canvas Sub Component	TV-CIRCMODE validated short-term Circular Economy Actions	LCSA implemented
TV_C1.1 Diversify circular activities	TV_A1.1.1 Increase recycled plastic content in TV components	rPC-ABS (30%) back cover
	TV_A1.1.2 Decrease packaging waste	100% recycled cardboard
TV_C2.3 Introduce and/or expand the use of ICT to foster circular economy	TV_A2.3.1 Use QR codes to provide information about materials and company's circularity to all the value chain	Remanufacturing
TV_C5.3 Change traditional relationships with customers, for instance: can a customer become a supplier?	TV_A5.3.1 Initiate a take back collection system in Europe with a partner	
	A1.1.5, A1.4.1, A2.1.1, A2.2.1, A5.3.1	

7.1 Functional unit and system boundaries

The product function for the TV set is to play multimedia content with image and sound. The functional unit considered in the study is one 43" TV set (GRUNDIG G43C 891 5A) with 10,784 hours of viewing during its 8-year lifetime (assuming an average use of 337 days/year and 4 h/day).[6]

Table 53 shows the system boundaries considered for the TV, identifying the life cycle phases, processes and other elementary flows included and excluded in the study.

Table 53. System boundaries considered for the TV set.

Life cycle phase	Included	Excluded
Raw material extraction and processing	Extraction of natural resources Refining and raw material production Intermediate product manufacturing Waste treatment and transport	Infrastructure
Product manufacturing	Energy for product manufacturing/assembly Transport	Infrastructure Production losses

7.2 Reference TV set social life cycle assessment

7.2.1 Social life cycle inventory

Primary data provided by ARÇELIK was used as the starting point to carry out the S-LCA. Specifically, it provided economic data describing the supply chain composition and location, identifying all the economic costs required to produce the TV set and the cost breakdown by countries and economic sectors. Table 54 shows the percentage breakdown of total production costs by countries and sectors.

Table 54. Production cost breakdown for the Reference TV set by countries and economic sectors.

Country/Sector	Plastic products	Ferrous metals	Paper products	Electronic equipment	Manufacturing process
TOTAL	10.268%	3.700%	0.837%	66.734%	18.461%
China	2.181%			49.527%	
Hong Kong	0.089%			0.255%	
Germany	0.009%			1.781%	
Turkey	7.918%	3.700%	0.837%	13.009%	18.461%

Taiwan	0.014%	1.649%	
Poland		0.027%	
Singapore		0.486%	
South Korea	0.057%		

The sectors included in the assessment comprise those related to every material and/or component required to produce the TV, as well as the sector linked to the manufacturing at ARÇELIK facilities (i.e., electronic equipment sector in Turkey). Electronic equipment and plastics are the most complex sectors in the supply chain since the related components come from 7 and 6 different countries, respectively, being Turkey and China those where more money is spent. By countries, China and Turkey are indeed the most important in the acquisition of materials and components, accounting both together for over 95% of total TV production costs.

The SHDB method and datasets were then used to calculate the social impacts for each sector in each country (as explained in Section 3 of the main document). The Social Hotspot 2019 Category Method with Weights (which is available for SimaPro software) was used. The social impacts derived from the TV set were obtained by allocating the production costs (in USD) to the corresponding social LCI datasets for every country-specific sector involved in the TV supply chain. The social LCI datasets used are listed in Table 55.

Table 55. Social LCI datasets for the country-specific sectors linked to the Reference TV set.

Social Hotspot Database (SHDB)	Reference Unit
Chemical, rubber, plastic products/CHN S	USD
Chemical, rubber, plastic products/HKG S	USD
Chemical, rubber, plastic products/DEU S	USD
Chemical, rubber, plastic products/TUR S	USD
Chemical, rubber, plastic products/TWN S	USD
Chemical, rubber, plastic products/KOR S	USD
Ferrous metals/TUR S	USD
Paper products, publishing/TUR S	USD
Mineral products nec/CHN S_China	USD
Electronic equipment/CHN S_China	USD
Electronic equipment/HKG S	USD
Electronic equipment/DEU S_Germany	USD
Electronic equipment/TUR S	USD
Electronic equipment/TWN S	USD
Electronic equipment/POL S	USD
Electronic equipment/SGP S_Singapore	USD
Manufactures nec/TUR S	USD

7.2.2 Social life cycle impact assessment

The social footprint of the TV set was calculated by aggregating the social impacts associated with each country-specific sector listed in Table 55 into a single social impacts indicator, namely the so-called Social Hotspot Index (SHI). Table 56 shows the SHI obtained for the TV, as well as its breakdown into the different social impact categories that contribute to the total social footprint.

Table 56. Social impacts of the Reference TV set by impact category.

Social category	Total impact (Pt)
Labour Rights & Decent Work	1,287.15
Health & Safety	1,601.17
Human Rights	843.00
Governance	2,024.31
Community	677.56
TOTAL: SHI	**6,433.19**

Figure 39 shows graphically the contribution of each social impact category to the total social footprint of the TV. It can be found that the greatest social impacts are due to Governance and Health & Safety issues, while social impacts affecting Community have the lowest contribution.

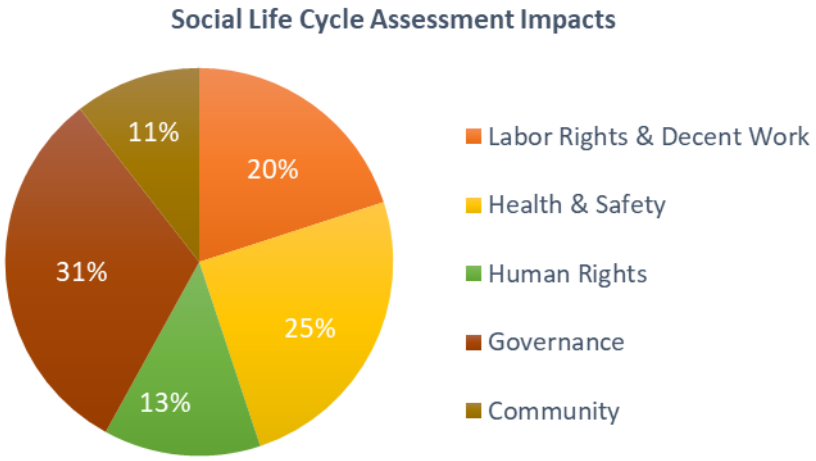

Figure 39. Percentage of impact categories in the social life cycle assessment for the Reference TV set

Social impacts by economic sectors

Figure 40 shows the economic share of each productive sector in the TV supply chain. The economic sector with the highest contribution (i.e., that in which the company spent more money to produce the TV) is the mineral products sector, followed by the electronic equipment sector and the EEE manufacturing process (at ARÇELIK facilities). Paper and ferrous metals are the economic sectors where expenditures are the lowest.

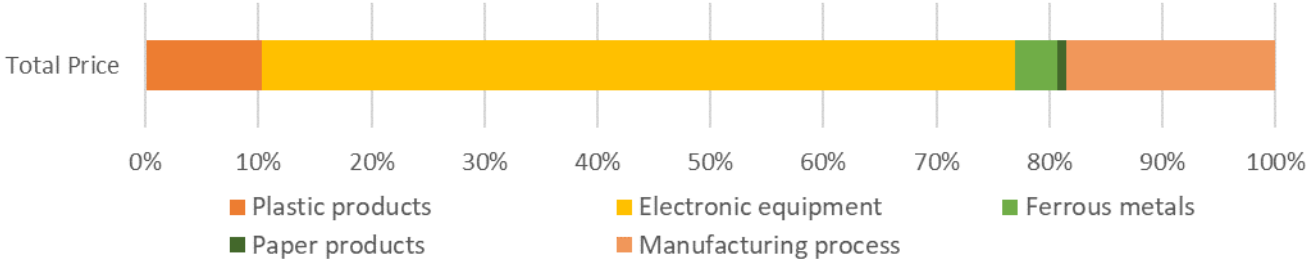

Figure 40. Production cost breakdown for the Reference TV set by economic sectors.

The social impacts were assessed for every economic sector. Table 57 shows the impacts for each social category obtained for each sector involved in the TV supply chain, while Figure 41 shows graphically the contribution by each sector to the total impact in each social category. The results show that the electronic equipment used in the TV set comprises most of the impact for every social category (with over 77% of total impacts). The manufacturing process conducted in ARÇELIK facilities (Turkey) and the plastics sector also have relevant contributions to social impacts. However, it should be noted that the impact contribution of these sectors are lower than their economic shares in total production costs, so their social risk levels are acceptable. Paper products and ferrous metals have negligible social impacts when compared to the other economic sectors composing the TV supply chain.

Table 57. Social impacts of the Reference TV set by economic sectors.

Economic sector	Labour Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
Plastic products	79.16	96.75	59.49	137.11	49.81
Electronic equipment	1,000.82	1,286.34	630.76	1,544.27	498.35

Ferrous metals	27.00	33.14	19.81	45.49	15.96
Metals	0.00	0.00	0.00	0.00	0.00
Paper products	5.15	5.60	3.58	8.16	3.18
Manufacturing process	175.02	179.33	129.35	289.28	110.26
TOTAL	**1,287.15**	**1,601.17**	**843.00**	**2,024.31**	**677.56**

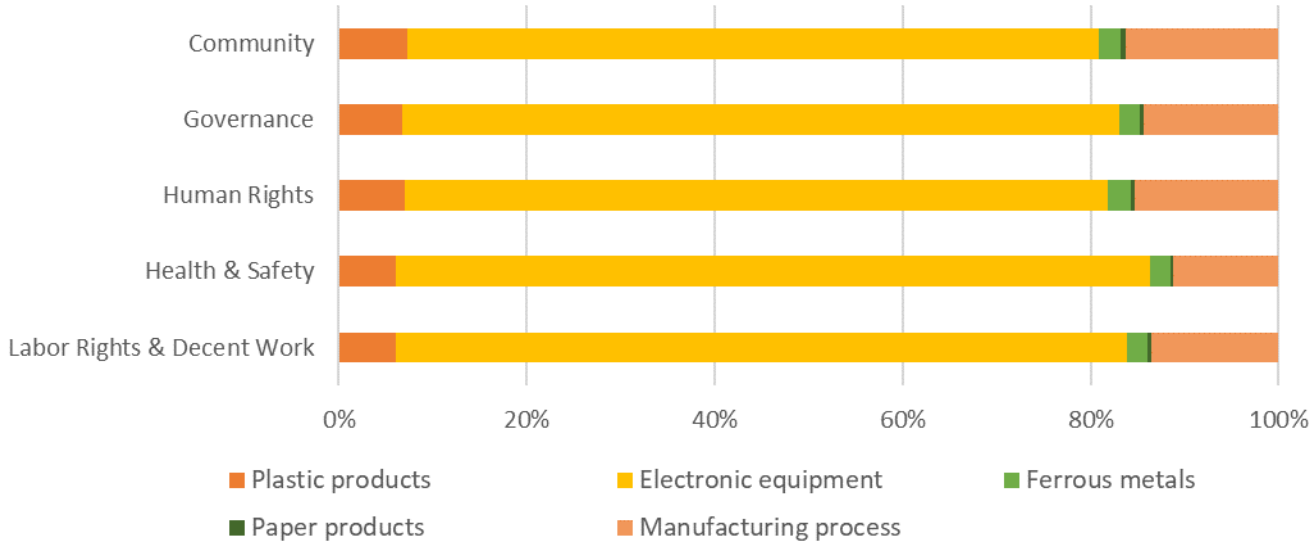

Figure 41. Contribution of each economic sector to the total social impacts of the Reference TV set by social category.

Social impacts by countries

Figure 42 shows the economic share of each country in the TV supply chain. The country with the highest contribution is China, comprising about 52% of the total TV production costs. It is followed by Turkey, which accounts for around 44% of the total TV production costs, including both the manufacturing costs at ARÇELIK facilities and the purchasing costs of various materials and components from other companies located in Turkey. The expenditure in the rest of countries is very low in comparison; e.g., Germany and Taiwan are the third and fourth countries with the largest contributions to total production costs, but these are less than 2% each.

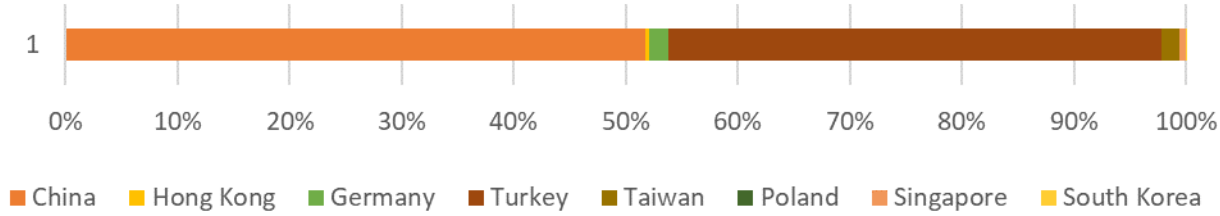

Figure 42. Production cost breakdown for the Reference TV set by country.

The social impacts were also assessed for every country in the TV supply chain. Table 58 shows the impacts for each social category obtained for each country, while Figure 43 shows graphically the contribution by each country to the total impact in each social category. The results clearly show that China is the country with the highest social impacts for all social categories. It comprises two-thirds of the total social impacts, while the remaining third is mainly attributable to Turkey. The social impacts of the other countries involved in the TV supply chain are comparatively negligible.

Despite China represents 52% of the total TV production costs, the social impacts there encompass between 65% and 70% of the total TV impacts depending on the social category assessed. This reveals that social risk levels in the Chinese productive sectors supplying ARÇELIK are high, so they can be identified as social hotspots

of the TV set. ARÇELIK should therefore investigate opportunities and measures together its Chinese suppliers to apply social improvements there, which could in turn derive in a decrease of the social footprint of the TV.

Turkey also represents a social hotspot due to its large contribution to total social impacts. ARÇELIK could devise measures for social improvement together its Turkish suppliers, although these should have a second order of priority behind the measures for China.

Table 58. Social impacts of the Reference TV set by country.

Economic sector	Labour Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
China	839.92	1,193.42	592.97	1,483.51	470.46
Hong Kong	2.97	4.11	1.13	2.51	0.86
Germany	4.87	8.85	3.81	6.21	2.36
Turkey	417.33	480.32	288.91	659.20	247.24
Taiwan	8.15	7.50	7.89	10.63	3.70
Poland	0.12	0.19	0.08	0.15	0.05
Singapore	3.39	3.70	2.31	4.42	1.90
South Korea	0.24	0.37	0.16	0.30	0.12
TOTAL	**1,276.99**	**1,698.46**	**897.25**	**2,166.93**	**726.69**

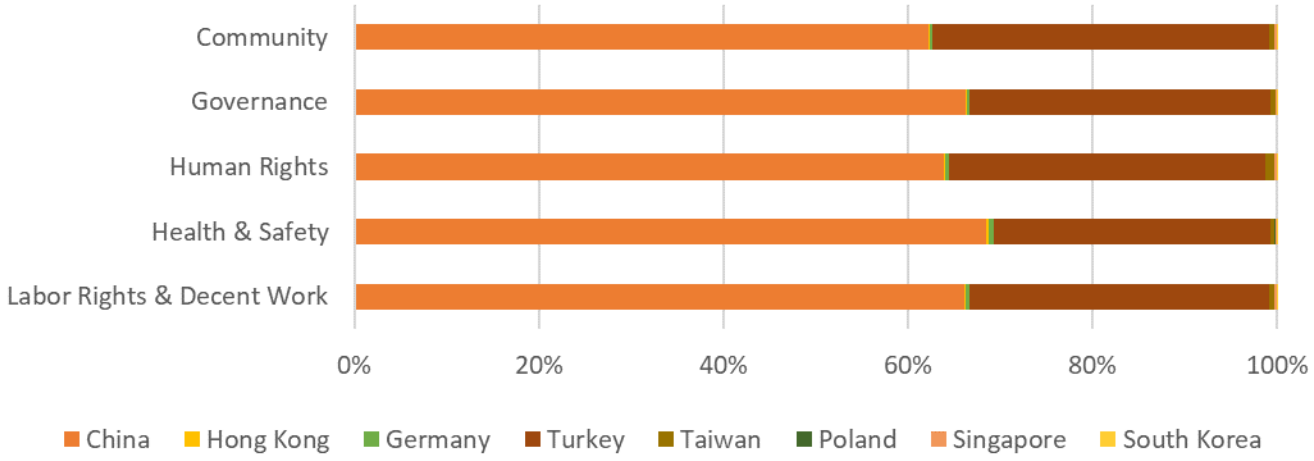

Figure 43. Contribution of each country to the total social impacts of the TV set by social category.

7.3 CSERVEES TV set social life cycle assessment

7.3.1 Redesign changes

Redesign changes implemented in the LCSA as described in Table 52 are detailed in Table 59. Recycled PC-ABS is used for the TV back cover and 100% recycled cardboard is used for the TV box. Most significantly, in C-SERVEES TV set, several components are reused for remanufacturing new TVs.

Table 59. C-SERVEES TV set changes implemented in LCSA.

	Reference	**C-SERVEES**	
Lifetime	8 years	8 years	
Functional units	10784	10784	
Recycled content	No recycled materials	30% recycled PC-ABS - Halogen Free	
		100 % recycled Cardboard	
Remanufacturing	No remanufacturing	**Components**	Replaced rate

Reference	C-SERVEES	
	Power cable	50%
	Back Cover	50%
	Plastic Stand Bracket	50%
	Wall Mount Bracket	50%
	Cable	50%
	T-con Board	50%
	Main Board	50%
	PSU Power Supply Unit	50%
	Loudspeaker	50%
	Wi-fi/Bluetooth Board	50%
	Front Plastic Cover	50%
	Display	50%
	Display Plastic Frame	50%
	Reflective plastic film	50%
	Led bar	50%
	Remote control	50%

7.3.2 Social life cycle inventory

Primary data provided by ARÇELIK was used as the starting point to carry out the S-LCA. Specifically, it provided economic data describing the supply chain composition and location, identifying all the economic costs required to produce the TV set and the cost breakdown by countries and economic sectors. Table 60 shows the percentage breakdown of total production costs by countries and sectors.

Table 60. Production cost breakdown for the TV CSERVEES set by countries and economic sectors.

Country/Sector	Plastic products	Ferrous metals	Paper products	Electronic equipment	Manufacturing process
TOTAL	5,754%	3,641%	0,837%	33,368%	56,400%
China	0,966%			24,854%	
Hong Kong				0,045%	
Germany	0,110%			0,892%	
Turkey	4,607%	3,641%	0,837%	6,497%	56,400%
Taiwan	0,014%			0,825%	
Poland				0,243%	
Singapore				0.486%	
South Korea	0,057%				

The sectors included in the assessment comprise those related to every material and/or component required to produce the TV, as well as the sector linked to the manufacturing at ARÇELIK facilities (i.e., electronic equipment sector in Turkey). Electronic equipment and plastics are the most complex sectors in the supply chain since the related components come from 7 and 5 different countries, respectively, being Turkey and China those where more money is spent. By countries, China and Turkey are indeed the most important in the acquisition of materials and components, accounting both together for over 97% of total TV production costs.

The SHDB method and datasets were then used to calculate the social impacts for each sector in each country (as explained in Section 3 of the main document). The Social Hotspot 2019 Category Method with Weights (which is available for SimaPro software) was used. The social impacts derived from the TV set were obtained by allocating the production costs (in USD) to the corresponding social LCI datasets for every country-specific sector involved in the TV supply chain. The social LCI datasets used are listed in Table 61.

Table 61. Social LCI datasets for the country-specific sectors linked to the C-SERVEES TV set.

Social Hotspot Database (SHDB)	Reference Unit
Chemical, rubber, plastic products/CHN S	USD

Social Hotspot Database (SHDB)	Reference Unit
Chemical, rubber, plastic products/HKG S	USD
Chemical, rubber, plastic products/DEU S	USD
Chemical, rubber, plastic products/TUR S	USD
Chemical, rubber, plastic products/TWN S	USD
Chemical, rubber, plastic products/KOR S	USD
Ferrous metals/TUR S	USD
Paper products, publishing/TUR S	USD
Mineral products nec/CHN S_China	USD
Electronic equipment/CHN S_China	USD
Electronic equipment/HKG S	USD
Electronic equipment/DEU S_Germany	USD
Electronic equipment/TUR S	USD
Electronic equipment/TWN S	USD
Electronic equipment/POL S	USD
Electronic equipment/SGP S_Singapore	USD
Manufactures nec/TUR S	USD

7.3.3 Social life cycle impact assessment

The social footprint of the TV set was calculated by aggregating the social impacts associated with each country-specific sector listed in Table 61 into a single social impacts indicator, namely the so-called Social Hotspot Index (SHI). Table 62 shows the SHI obtained for the TV, as well as its breakdown into the different social impact categories that contribute to the total social footprint.

Table 62. Social impacts of the C-SERVEES TV set by impact category.

Social category	Total impact (Pt)
Labour Rights & Decent Work	1,287.15
Health & Safety	1,601.17
Human Rights	843.00
Governance	2,024.31
Community	677.56
TOTAL: SHI	**6,433.19**

Figure 44 shows graphically the contribution of each social impact category to the total social footprint of the TV. It can be found that the greatest social impacts are due to Governance, Health and Safety issues, while social impacts affecting Community have the lowest contribution.

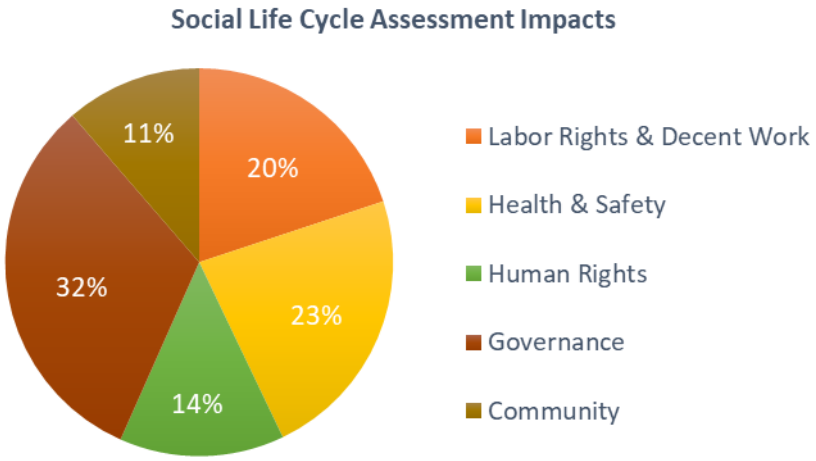

Figure 44. Percentage of impact categories in the social life cycle assessment for the C-SERVEES TV set

Social impacts by economic sectors

Figure 45 shows the economic share of each productive sector in the TV supply chain. The economic sector with the highest contribution (i.e., that in which the company spent more money to produce the TV) is the manufacturing process, followed by the electronic equipment sector and the plastic products (at ARÇELIK facilities). Paper and ferrous metals are the economic sectors where expenditures are the lowest.

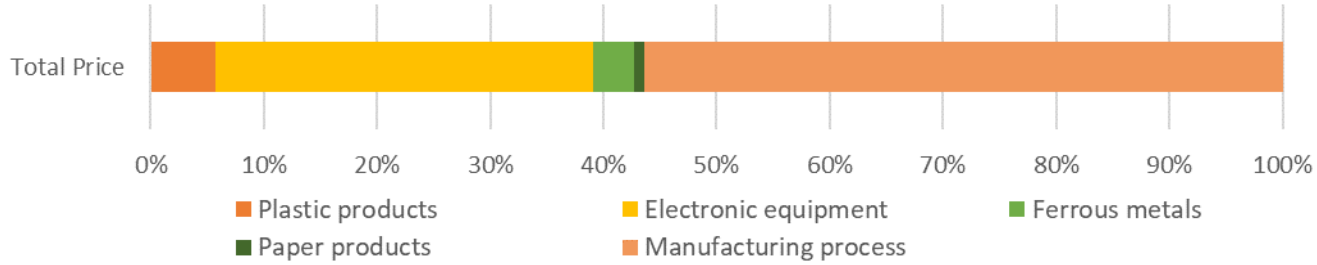

Figure 45. Production cost breakdown for the C-SERVEES TV set by economic sectors.

The social impacts were assessed for every economic sector. Table 63 shows the impacts for each social category obtained for each sector involved in the TV supply chain, while Figure 46 shows graphically the contribution by each sector to the total impact in each social category. The results show that the electronic equipment and manufacturing used in the TV set comprises most of the impact for every social category (with over 93% of total impacts). The impact contribution of the electronic equipment acquired is high compared to their economic share in total production costs, which is around 33%. This means that the social risk levels in this sector, which is practically located in China, are high compared with other sectors in the TV supply chain, so it presents a social hotspot to be considered when planning measures to improve social conditions and reduce the social footprint of the TV set. The manufacturing process conducted in ARÇELIK facilities (Turkey) and the plastics sector also have relevant contributions to social impacts. However, it should be noted that the impact contribution of these sectors is lower than their economic shares in total production costs, so their social risk levels are acceptable. Paper products and ferrous metals have negligible social impacts when compared to the other economic sectors composing the TV supply chain.

Table 63. Social impacts of the C-SERVEES TV set by economic sectors.

Economic sector	Labour Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
Plastic products	40.89	49.06	31.08	70.96	26.04

Electronic equipment	501.10	643.97	315.97	773.68	249.64
Ferrous metals	26.57	32.61	19.50	44.77	15.71
Metals	0.00	0.00	0.00	0.00	0.00
Paper products	5.15	5.60	3.58	8.16	3.18
Manufacturing process	534.71	547.88	395.19	883.78	336.86
TOTAL	**1,108.41**	**1,279.12**	**765.32**	**1,781.35**	**631.42**

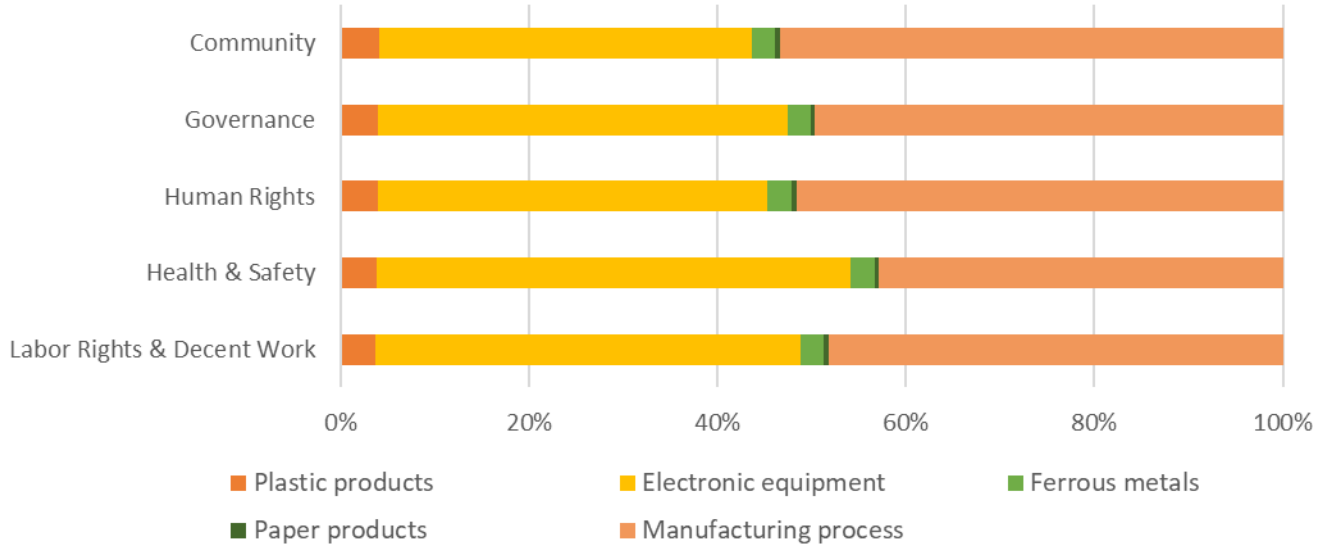

Figure 46. Contribution of each economic sector to the total social impacts of the C-SERVEES TV set by social category.

Social impacts by countries

Figure 47 shows the economic share of each country in the TV supply chain. The country with the highest contribution is China, comprising about 52% of the total TV production costs. It is followed by Turkey, which accounts for around 44% of the total TV production costs, including both the manufacturing costs at ARÇELIK facilities and the purchasing costs of various materials and components from other companies located in Turkey. The expenditure in the rest of countries is very low in comparison; e.g., Germany and Taiwan are the third and fourth countries with the largest contributions to total production costs, but these are less than 2% each.

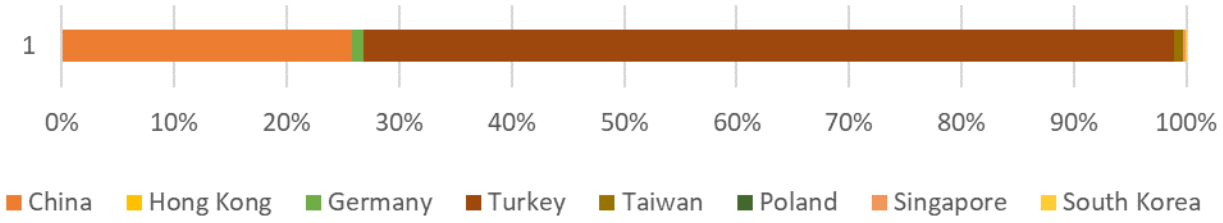

Figure 47. Production cost breakdown for the TV CESERVEES set by country.

The social impacts were also assessed for every country in the TV supply chain. Table 64 shows the impacts for each social category obtained for each country, while Figure 48 shows graphically the contribution by each country to the total impact in each social category. The results clearly show that Turkey is the country with the highest social impacts for all social categories. It comprises two-thirds of the total social impacts, while the remaining third is mainly attributable to China. The social impacts of the other countries involved in the TV supply chain are comparatively negligible.

Despite Turkey represents 75% of the total TV production costs, the social impacts there 61% of the total TV impacts depending on the social category assessed. This reveals that social risk levels in the ARÇELIK Turkey productive sectors are acceptable.

Table 64. Social impacts of the C-SERVEES TV set by country.

Economic sector	Labour Rights & Decent Work	Health & Safety	Human Rights	Governance	Community
China	839.92	1,193.42	592.97	1,483.51	470.46
Hong Kong	2.97	4.11	1.13	2.51	0.86
Germany	4.87	8.85	3.81	6.21	2.36
Turkey	417.33	480.32	288.91	659.20	247.24
Taiwan	8.15	7.50	7.89	10.63	3.70
Poland	0.12	0.19	0.08	0.15	0.05
Singapore	3.39	3.70	2.31	4.42	1.90
South Korea	0.24	0.37	0.16	0.30	0.12
TOTAL	**1,276.99**	**1,698.46**	**897.25**	**2,166.93**	**726.69**

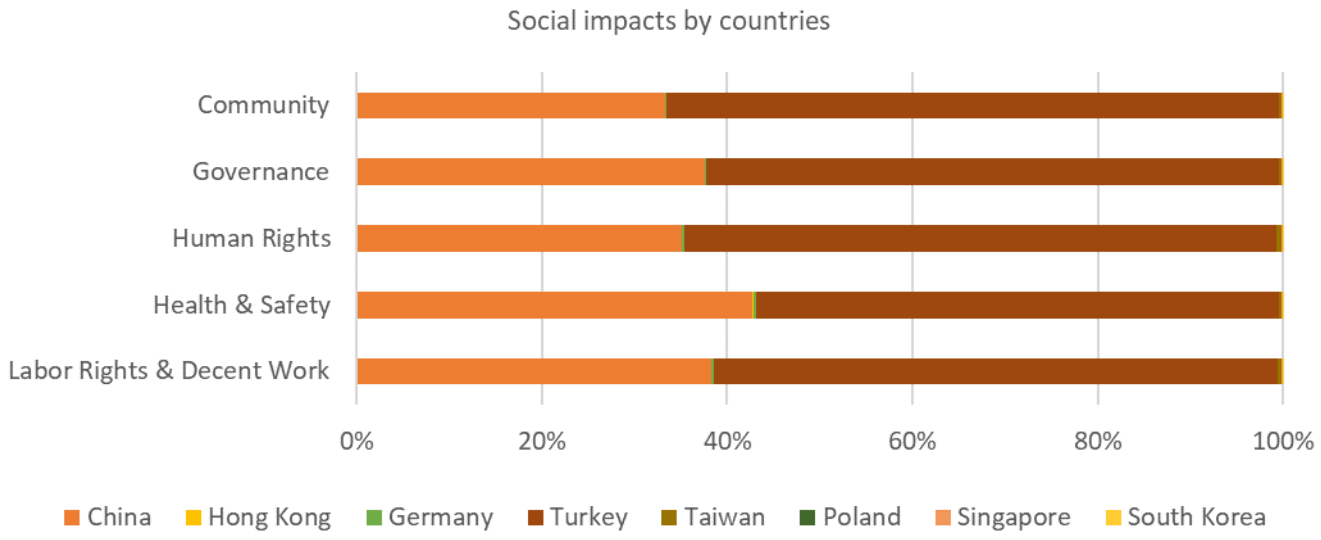

Figure 48. Contribution of each country to the total social impacts of the C-SERVEES TV set by social category.

7.4 TV sets comparative social life cycle assessment

Circularity enhancement of the C-SERVEES TV set is performed with the same cost amount although with different cost breakdown than the linear Reference TV set. Table 65 and Figure 49 show the social impact of the reference and the CSERVEES products for one functional unit. It can be clearly seen how reusing part of the product's modules for remanufacturing reduces the social impact of the production process. The reduction of new component from Chine thanks to the remanufacturing reduce social impacts 7-20%.

Table 65. TV sets comparative S-LCA for one watched hour.

Units: Pts	Reference	C-SERVEES	Relative reduction
Labor Rights & Decent Work	0.12	0.10	13.9%
Health & Safety	0.15	0.12	20.1%
Human Rights	0.08	0.07	9.2%
Governance	0.19	0.17	12.0%
Community	0.06	0.06	6.8%
Total	0.60	0.52	13.5%

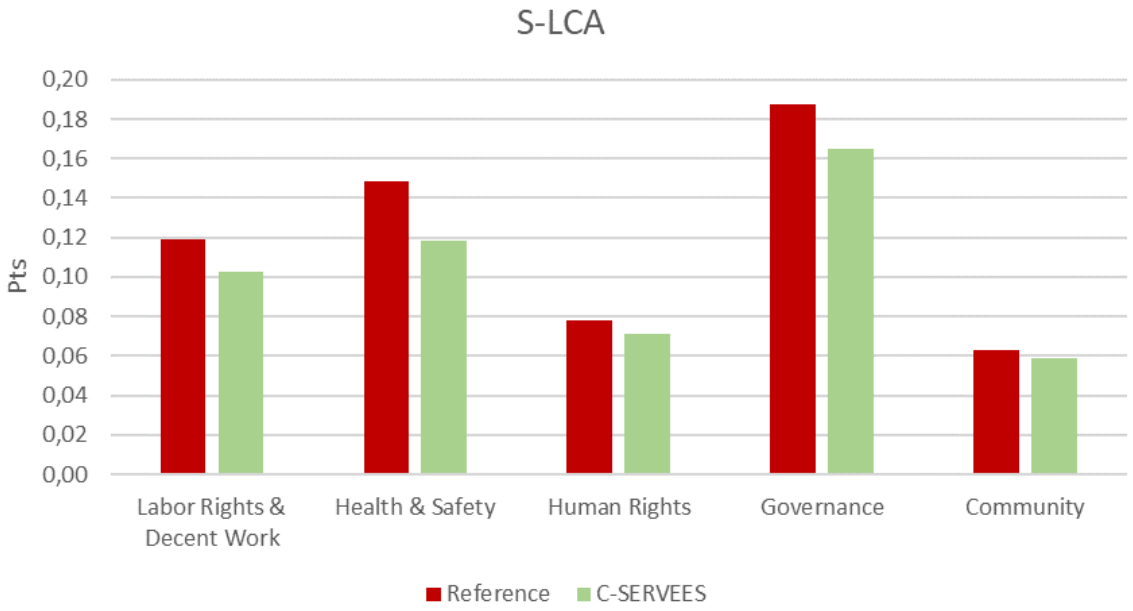

Figure 49. TV sets comparative S-LCA.

8 Conclusions

This Deliverable 5.4 validates the social feasibility of the target products and related eco-services of the new business circular models developed in the C-SERVEES project that aims to boost a resource-efficient circular economy in the electrical and electronic sector by means of demonstrations involving four target products: washing machines, multifunctional laser printers and their toner cartridges, telecom equipment and TV sets. These products belong to different EEE categories that jointly account for 77% of the WEEE collected in the EU.

It is worth mentioning EMAUS activity, the NGO which has raised the Project social and solidarity opportunities and has been involved in the refurbishment of WM.

This activity has multiple benefits: an environmental benefit (avoiding waste generation, the use of raw materials and energy, as well as the pollution generated by these production processes) and slows climate change, an economy one due to the quality and solidarity employment and a social benefit because of the workers inclusivity.

The social impacts for the four target products were calculated using the S-LCA methodology. A cradle-to-gate assessment was applied, meaning that the scope of the social assessment covered from the extraction and processing of raw materials to the delivery of the finished product at the factory gate. In particular, the method and the indicators of the Social Hotspot Database were used. It allows to calculate social impacts for 26 social subcategories grouped into 5 categories. The SHDB offers a weighted aggregation model that converts the impact values of the social subcategories into aggregate impact values for each social category, which in turn can be aggregated into a single global social footprint for the products (the so-called Social Hotspot Index or SHI).

Two different types of scenarios are assessed and compared for each target product to validate the sustainability of the new circular business models:

- A conventional scenario, in which the products are produced and consumed under linear economy models.
- The C-SERVEES scenario, in which the products are produced and consumed under the new circular economy models relying on the eco-innovative services demonstrated in the project.

This Deliverable 5.4 shows the social life cycle assessment of each target product under the conventional scenario, called Reference product, and under the C-SERVEES scenario, called C-SERVEES product. The impacts of the C-SERVEES scenario are also compared to those for the conventional scenario to calculate the social benefits that can be achieved with the solutions developed in the project.

The main conclusion of this Deliverable 5.4 is that the four target products under the new circular economy models relying on the systemic eco-innovative services demonstrated in the project have reduced social impacts by an average of 15%. Conclusions for each target product are as follow:

Washing machine: Circularity enhancement of the washing machine is performed with the same amount and cost breakdown as the linear washing machine. Consequently, the C-SERVEES washing machine and the reference washing machine have the same social impact. The lack of reduction of social impacts is not relevant given that the country with by far the largest contribution is Turkey, which accounts for about 90% of total washing machine production costs.

Multifunction laser printer: Circularity enhancement of the C-SERVEES printer is performed with the same cost amount although with different cost breakdown than the linear Reference printer. Reducing production costs in China by 5% shifted to remanufacturing in Mexico resulted in a decrease in social impacts by 0.8% on average.

Telecom equipment: The inclusion of ICT improves maintenance monitoring and allows for a longer service life of 8 to 15 years and the 10 % reuse of the components for the central ALM unit. Positively, social impacts are reduced 47% while the production cost is similar. Germany and China are the countries with the highest social impacts for all social categories. Despite China represents only 6.5% of total production costs, the social impacts there encompass between 30% and 47% of the total ALM product impacts depending on the social category assessed. Oppositely, the case of Germany is positively remarkable since it covers 82% of total ALM production costs, including both product manufacturing and supplies purchased there, but it only causes between 45% and 61% of total social impacts.

TV set: Circularity enhancement of the C-SERVEES TV set is performed with the same cost amount, although with different cost breakdown than the linear Reference TV set. Components reuse for remanufacturing reduces 7-20% the social impact of the production process. Specifically important for the social impact improvement is the reduction of new components supplied from Chine thanks to the remanufacturing.

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