Paving the way for innovative circular economy products and services

C-SERVEES PROJECT FINAL REPORT

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DISCLAIMER

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ACRONYMS

ALM	Access Link Monitoring
ALM-CIRCMODE	Circular Business Model – Access Link Monitoring
B2B	Business to Business
B2C	Business to Consumer
BM	Business Model
C-SERVEES	Activating **C**ircular **Serv**ices in the **E**lectric and **E**lectronic **S**ector Project
CE	Circular Economy
CEBM	Circular Economy Business Model
CI	Circularity Indicators
CIRCMODE	Circular Model
CMRT	Conflict Minerals Reporting Template
CRM	Critical Raw Materials
DSS	Decision Support System
E-LCA	Environmental Life Cycle Assessment
E&E	Electrical & Electronic
EEE	Electrical and Electronic Equipment
EoL	End of Life
EU	European Union
GHG	Greenhouse Gases
GWP	Global Warming Potential
ICT	Information and Communication Technology
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
LCSA	Life Cycle Sustainability Assessment
MCI	Material Circularity Indicator
MPS	Managed Print Service
NGO	Non-Governmental Organisation
OEM	Original Equipment Manufacturer
PaaS	Product as a Service
PBDE	Polybrominated Diphenyl Ether

POPS	Persistent Organic Pollutants
PRINT-CIECMODE	Circular Business Model – Printer
PSS	Product Service Systems
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
ReCiPe	A methodology that provides a 'recipe' to calculate life cycle impact category indicators. The acronym represents the initials of the institutes that were the main contributors to this project and the major collaborators in its design: Netherlands National Institute for Public Health and the Environment, Radboud University, Institute of Environmental Sciences (University of Leiden) and PRé Consultants.
REF-CIRCMODE	Circular Economic Business Reference Model
S-LCA	Social Life Cycle Assessment
SHDB	Social Hotspot Database
SVHC	Substances of Very High Concern
TV-CIRCMODE	Circular Business Model - Television
UPR_{10}	Use-phase-over-Production-phase Ratio
WASH-CIRCMODE	Circular Business Model – Washing Machine
WEEE	Waste of Electrical and Electronic Equipment

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Executive Summary

The C-SERVEES project set out to advance the circularity in the EEE sector through the design of circular business models applied to the design of products as well as to the way they are manufactured, distributed and disposed of.

In order to foster the adoption of circular economy business models (CEBMs), a conceptual framework to classify CEBMs was designed. Guidelines for the application of that framework were translated into business models centred on washing machines, printers, telecom equipment and TVs which ADVA, Lexmark and Arçelik, the original equipment manufacturers involved in the project, demonstrated. Four key things in particular were explored: eco-design, eco-leasing, improved WEEE management and ICT services. Surveys, amongst other things, aided in testing end-users' acceptance.

ICT tools were developed to support the CEBMs and enhance their effectiveness, and to enable value chain transparency while maintaining the necessary confidentiality. They also offer support to stakeholders to connect with each other and share useful resources. Finally, the tools support the reverse logistics that enable effective return of products.

The demonstrations were made subject to a life cycle sustainability assessment to assess their performance in relation to environmental life cycle assessment, life cycle costing and social life cycle assessment. To that evaluation was added a social/cultural acceptance and perception analysis.

Finally, the project offers a set of policy recommendations to foster market opportunities and effectively address the barriers.

1 Introduction

C-SERVEES aims to change the way electronic and electrical (E&E) products are developed and consumed and to make all stakeholders think about new approaches to their design and production, distribution and use, and end-of-life (EoL).

The overall principles of circular economy (CE) are generally accepted but integrating them in business models remains challenging. Despite various types of drivers, the adoption of circular economic business models (CEBMs) in the sector of electrical and electronic equipment (EEE) is not widespread. The lack of a conceptual framework to classify or denominate CEBMs and the concomitant uncertainty around the benefits of CEBMs makes matters worse.

The C-SERVEES project addresses these challenges by developing a CEBM for the EEE sector, including guidance for its implementation by manufacturers developing product-specific business models. It then adapts and applies this CEBM to four items of EEE: washing machines, printers, telecom equipment and TVs.

Four demonstrations were undertaken in the project, each focussing on one of these four products. Central to these demonstrations were the original equipment manufacturers involved in the project, ADVA, Arçelik and Lexmark. The demonstrations were aimed at testing and validating the new CEBMs by integrating four basic pillars: eco-design, eco-leasing, improved WEEE management and ICT services. In addition, the testing of end-users' acceptance was addressed via surveys and living labs.

The project has also developed three ICT tools to support the effective use of the CEBMs through value chain transparency, connect stakeholders with each other and enable optimised reverse logistics.

The project also conducted an evaluation of the proposed solutions by applying life cycle sustainability assessment (LCSA) to the demonstrations to measure their performance in relation to the three pillars of sustainability: environmental life cycle assessment (E-LCA), life cycle costing (LCC) and social life cycle assessment (S-LCA). Furthermore, this evaluation is complemented with a socio-cultural acceptance and public perception analysis to establish how end users and society perceive the problems associated with e-waste and its management, as well as their acceptance of the new circular products and services provided.

Finally, the project identified opportunities and barriers, and provides a set of recommendations to foster the opportunities and overcome the barriers.

This report provides a high-level summary of the activity, results and recommendations of C-SERVEES. For detailed insight visit the publications section of the project website, which provides links to the reports produced during the course of the research, including those submitted to the European Commission.

2 Circular Economy Business Models

2.1 Background

Although the concept and principles of Circular Economy are generally acknowledged and accepted, it is proving more difficult to implement. To date, the adoption of circular economic business models in the electrical and electronic equipment sector has been piecemeal despite regulatory, business, and economic drivers. This is compounded by the lack of an integrated sector-wide circularity approach and accepted framework for depicting CEBMs; and exacerbated by stakeholders' uncertainly of the potential benefits of CEBMs for their businesses. C-SERVEES addressed these sectoral and organisational challenges through two concurrent tasks: (1) develop a circular economic business reference model for the EEE sector (REF-CIRCMODE), which includes a step-by-step guidance for its implementation by EEE manufacturers to develop product-specific CEBMs; and (2) apply and validate that model to develop CEBMs for washing machines, printers, telecom ADVA Optical Networking products and tv sets and displays.

2.2 Method

The design and development of C-SERVEES CEBMs comprised 10 stages:

1. Carrying out surveys to collect information from a range of EEE stakeholders on CE awareness and CEBM development and implementation barriers and opportunities. This enabled C-SERVEES to engage extensively with key stakeholders across 13 European countries throughout the entire EEE value chain, including designers, manufacturers, retailers, business users, household users and recyclers.

2. Identifying EEE stakeholders' business and operational requirements regarding the adoption and implementation of CEBMs.
3. Classifying the main existing CEBMs, including Product Service Systems (PSS) and leasing models, and evaluating their relevance to the EEE sector.
4. Identifying EU and national CE-related policy documents relevant to the EEE sector.
5. Theming and categorising circularity indicators that support the measurement of CE performance.
6. Generating a consolidated five-layered circular economic business reference model for the EEE sector (REF-CIRCMODE).
7. Producing a seven-step guidance to use REF-CIRCMODE as a framework to develop EEE product-specific CEBMs.
8. Mapping the layered structure of REF-CIRCMODE to develop four product-specific CEBMs for washing machines; printers; telecom ALM; and TV sets and displays.
9. Adding greater granularity to the five layers of the C-SERVEES product-specific CEBMs in accordance with products' specifications, current business models, and organisational CE objectives and aspirations.
10. Producing short, medium, and long-term 'CE Actions' for the four C-SERVEES product-specific CEBMs, of which the short-term 'CE Actions' were implemented in large-scale demonstrations.

2.3 Results

The REF-CIRCMODE structure, which provides a framework encompassing all possible CE options at strategic level, as well as for each stage of a product's lifecycle, comprises five associated layers starting with an overarching 'Business Strategy' that underpins four concurrent layers encompassing CEBM Canvas; challenges & opportunities; policies; and circularity indicators.

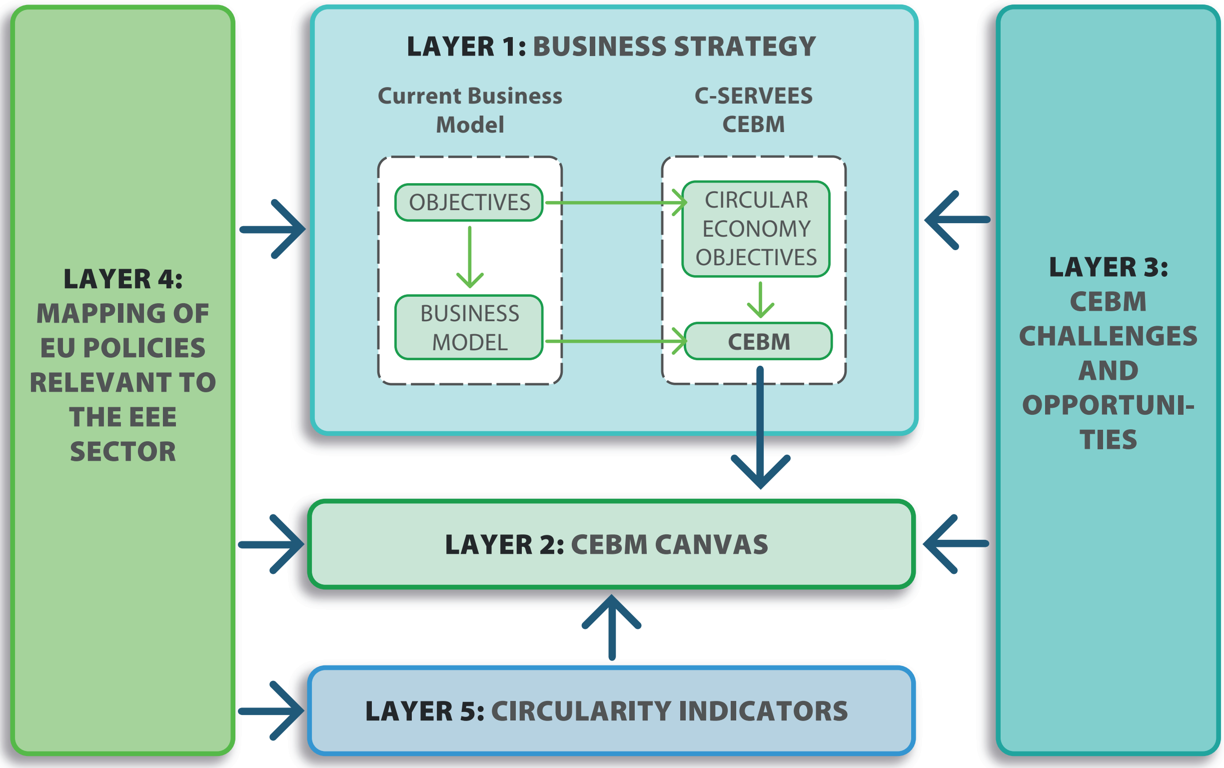

Figure 1 *REF-CIRCMODE structure developed in C-SERVEES*

Layer 1 maps out the 'Business Strategy' and represents an informed shift from current 'Business Model Objectives' to 'CEBM Objectives', and respective 'CEBM Canvas' categories and sub-categories/ CE activities.

Layer 2 represents the 'CEBM Canvas', which comprises 9 categories (C1-C9) and 36 associated sub-categories/CE activities. Each of the sub-components relates to a pursuit that the business may already be exploring. Working through the REF-CIRCMODE Canvas offers the opportunity to identify and assess all possible circular options that are related to each sub-component.

Layer 2 Components	Layer 2 Sub-Components	Example Circular Economy Actions
Key Circular Activities	1.1 Diversify circular activities	A1.1 Expand product and component recovery and refurbishment programme
	1.2 Embrace eco-design	A1.2 Design to improve the durability of products and components
	1.3 Circular production strategies	A1.3 Continously audit production and suppliers production against circularity indicators
	1.4 Circular logistics and distribution	A1.4 Improve reverse logistics for greater product take-back
	1.5 Repair and maintenance services	A1.5 Explore competitivness of 3D printing for smaller plastic parts for repair
	1.6 End-of-life circularity	A1.6 Provide recyclers with material declaration to aid recycling
	1.7 Track materials and components	A1.7 Material labels or tags (RFID, QR) for recycling
Key Circular Resources	2.1 Competitive financing models	A2.1 Conduct cost analysis on secondary/virgin materials
	2.2 Skills and training programmes	A2.2 Improve promotion and training of circular economy for sub-contractors
	2.3 Use of ICT	A2.3 Use ICT to improve information sharing across the supply chain
Key Circular Partnerships	3.1 New alliances/existing partnerships	A3.1 Improve partnerships with component suppliers
	3.2 Private/public procurement	A3.2 Form partnerships to expand the customer base
	3.3 Partnerships' cultural issues	A3.3 Active media/PR campaign on refurbished products
Key Customer Segments	4.1 B2B/B2C customer segments	A4.1 Ensure refurbished products are desirable to environmental conscious customers
	4.2 Cultural patterns	A4.2 Target 'green conscious' B2B customers
	4.3 Social class/demographic segments	A4.3 Study networks of resellers to take advantage of a long-term B2C market
Circular Customer Relationships	5.1 Customer relationships initiatives	A5.1 Offer/discuss circular solutions with dedicated customers
	5.2 Social media platforms	A5.2 Enable customer circular economy requirements' feedback via company platforms
	5.3 Change traditional relationships	A5.3 Existing/new contracts modified to provide extra support for takeback/buyback
	5.4 After-sales services	A5.4 Provide enhanced after sales services and /warranty for circular offerings
Circular Customer Relationships	6.1 Customer communications	A6.1 Use ICT platfforms to disseminate and communicate circular economy offerings
	6.2 Brand and organisation's image	A6.2 Inclusion of circular activities when participating in events/symposia
	6.3 Eco-labelling and certificates	A6.3 Participate in eco-labelling cartification and/or standards for circular economy
	6.4 Data security	A6.4 Address data security issues for returned/refurbished equipment
	6.5 Marketing strategies	A6.5 Include circular economy messages in bilateral communication
Circular Value Proposition	7.1 Products as a service/bundles	A7.1 Introduce a Product Service System offering to complement current portfolio
	7.2 Leased, rented or shared product	A7.2 Explore the Potential for shared products through simulation and calculation
	7.3 Sustainable comsumption patterns	A7.3 Leverage the use of blockchain based ICT tools to improve printers' circularity
	7.4 Circular end-of-life options	A7.4 Learn from best practice to improve the product collection/return programme
Circular Revenue Streams	8.1 Recurring revenues	A8.1 Incentivize customer returns of end-of-use product for high-end product lines
	8.2 Financial administration	A8.2 Explore renting or leasing options for medium size B2B customers
	8.3 Value from waste	A8.3 Reuse end-of-life parts in refurbished products
Circular Cost Structure	9.1 Mitigate additional costs	A9.1 Reduce legislative compliance fees for WEEE management via collection programme
	9.2 Manufacturing and sales processes	A9.2 Reduce the costs of design for recycling measures
	9.3 Cost of take-back and return	A9.3 Improve tracking and reverse logistics system to mitigate costs with returned products
	9.4 Lower lifetime costs over initial cost	A9.4 Expose the real, hidden cost of waste management to consumers

Figure 2 *C-SERVEES REF-CIRCMODE Canvas*

Layer 3 examines and assesses CEBM implementation, economic, technical, supply chain and social challenges and opportunities that are related to each REF-CIRCMODE Canvas sub-component/ activity in Layer 2.

Layer 4, which enables an assessment of CE policy documents relevant to EEE products, offers the opportunity to identify additional voluntary or added value policy documents.

Layer 5 identifies and evaluates 'Circularity Indicators' (CIs) to measure circularity of the target EEE products. CIs are clustered into four themes in line with the lifecycle stages of EEE products, and nine associated specific CIs.

REF-CIRCMODE acts as a framework for implementing a CEBM for any EEE product. It presents a series of options, which may, or may not, be applicable to a given product but are included initially to be debated at the implementation stage and, if inappropriate, discarded or delayed. As such, 'REF-CIRCMODE Implementation Guidance', which encompasses seven interrelated steps, has been devised to assist EEE stakeholders, particularly manufacturers, to instigate and put into practice a CEBM for any given EEE product.

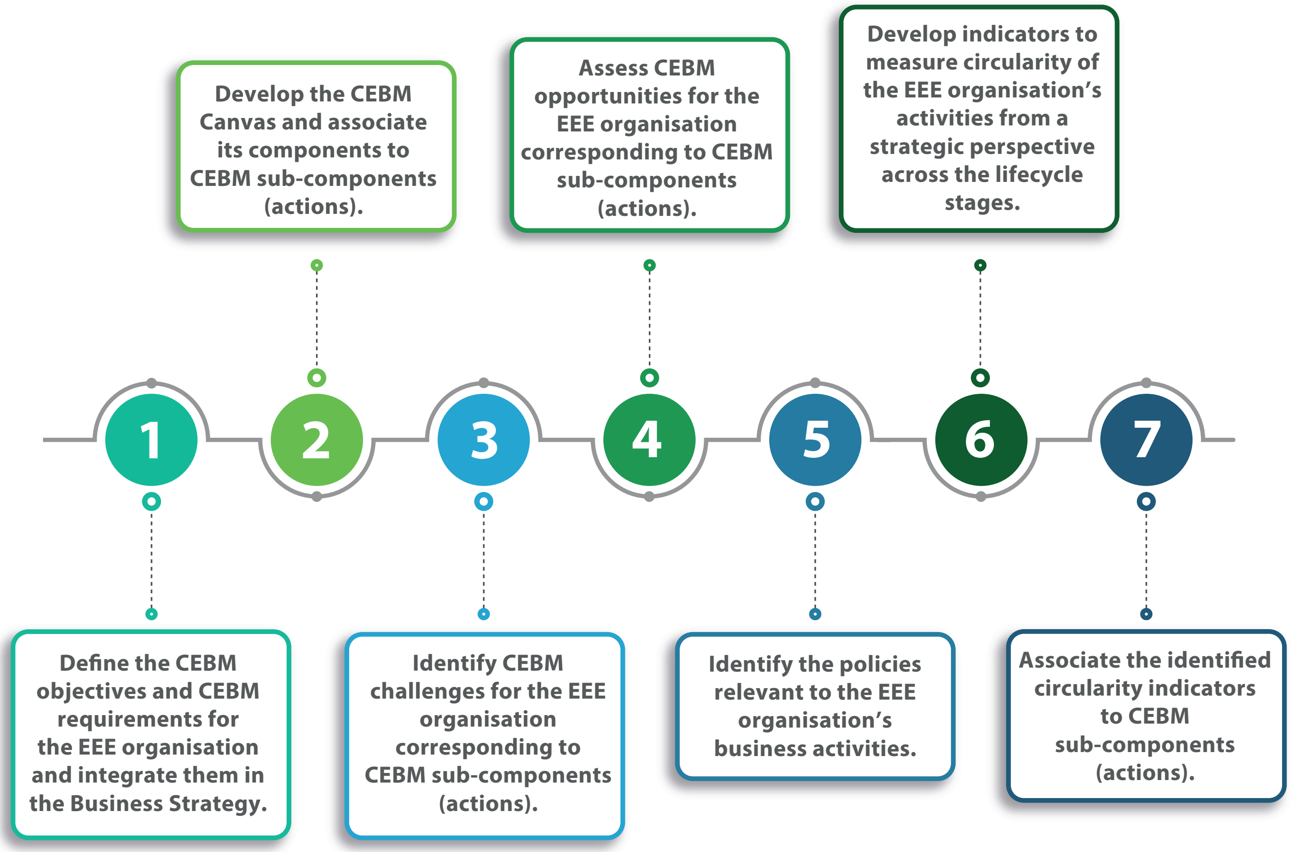

Figure 3 *The 7 steps of the REF-CIRCMODE implementation guidance*

The five layered REF-CIRCMODE structure and implementation guidance have been used to develop four product-specific CEBMs for washing machines (WASH-CIRCMODE); printers (PRINT-CIRCMODE); telecom ALM (ALM-CIRCMODE); and TVs (TV-CIRCMODE). A new Layer 0 was added in the form of a specification document that covers general, technical, and environmental information for each of the four C-SERVEES products. The final stage of the development of the four product-specific CEBMs culminated in the identification of a range of short, medium, and long-term 'CE Actions', of which short-term 'CE Actions' were selected for implementation in the C-SERVEES large-scale demonstrations that were underpinned by a respective 'CE Action Plan'.

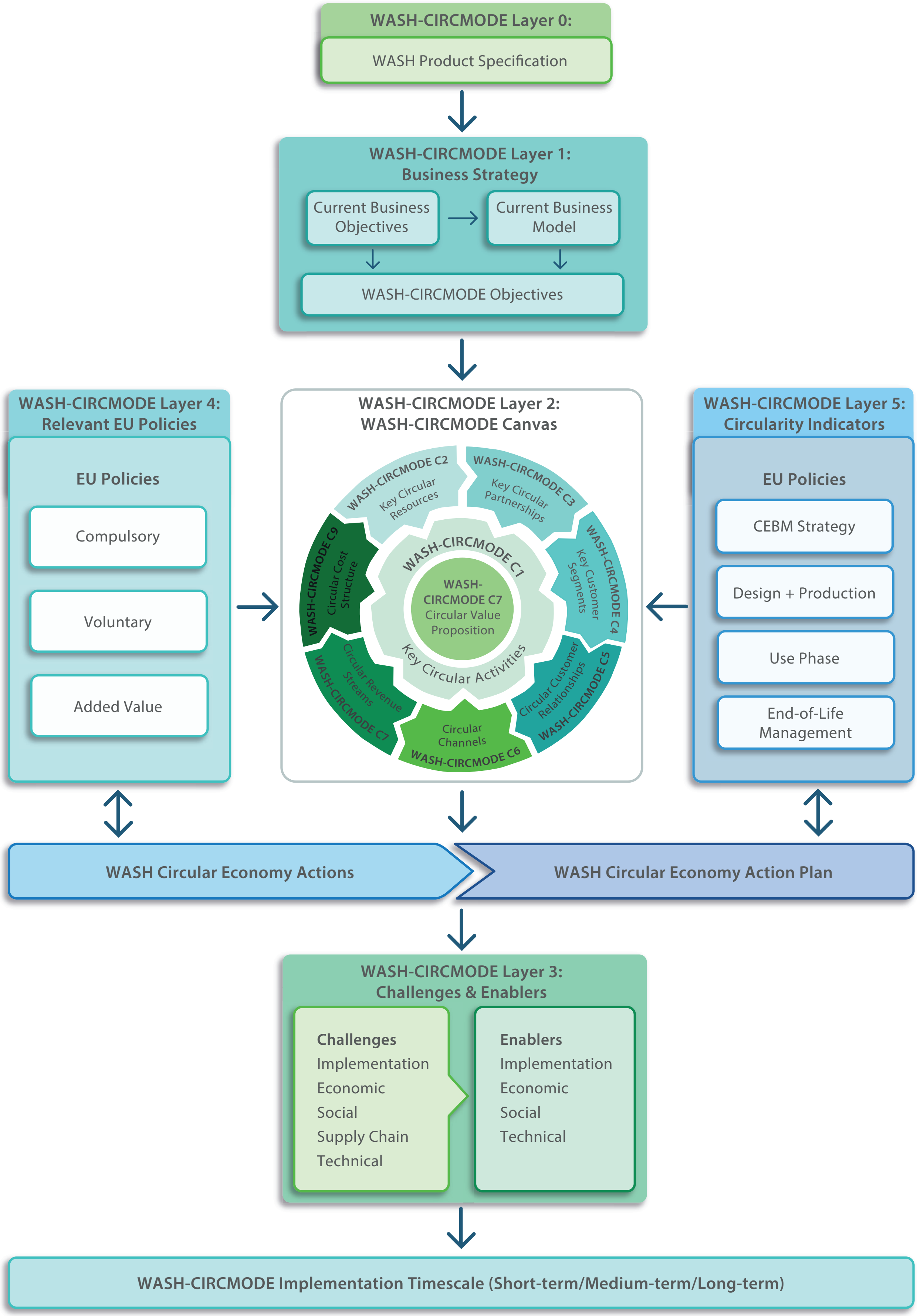

Figure 4 *Detailed REF-CIRCMODE structure with Layer zero*

3 ICT Tools

3.1 Background

ICT tools were developed to support the CEBMs and enhance their effectiveness and to enable value chain transparency while maintaining the necessary confidentiality. They also offer support to stakeholders to connect with each other and share useful resources. Finally, the tools support the reverse logistics that enable effective return of products.

C-SERVEES argues that supply chain transparency is crucial for circular economy as the knowledge about the materials, components and production processes enables their circularity. Furthermore, there are indirect benefits in the fact that companies use sustainability parameters for marketing of their products as higher quality products for a more expensive product line. Besides, upcoming regulations responding to the EU Green Deal and the circular economy Action Plan also require steps towards more transparency in some sectors. In many companies, data about the supply chain can only be gathered in a slow, unscalable, and manual fashion and in different data formats. This process is not scalable and does not allow companies to adjust and finetune the amount of data they want to share as the material data has switched ownership.

As part of a sustainable and circular value chain, the efficient management of the reserve logistics for the recovery of products enables savings on transport costs, reduces greenhouse gas emissions due to more efficient journeys, contributes to reducing the final cost of the products, increases the attractiveness of reused/second-hand materials and increases environmentally responsible behaviour.

In addition, the ability for stakeholders across the value chain to connect with one another, enables information to be exchanged that can increase the useful life of the product.

3.2 ICT Tools functionalities

C-SERVEES has integrated a blockchain-based transparency solution to provide absolute proof for the circular economy, sustainability and recycling practices of manufacturers at any stage of the supply chain. This tool enables value chain transparency without disclosure of datasets or supply chain partners. The solution uses decentralised, encrypted data to track material and product characteristics, e.g. whether, and which proportion of recycled materials have been employed.

The system uses blockchain technology to make supply chains transparent and certify materials. In comparison to paper-based information sharing, which in 65% of the cases does not fully cover tier 1 suppliers, the system does not require the entire supply chain to be known, cooperating, or certified. The technology decreases auditing and production costs due to a smaller number of audited parties. Claims that allow for validation are traded directly from the material manufacturer to the brand owner. The resulting affordable proof of material will raise the market share of sustainable products by 5% and make them attainable for average customers. The possibility to increase revenue through circular economy business models makes it an intrinsically motivated development which will make supply chain transparency a standard.

The C-SERVEES Logistic Platform offers the possibility to define, simulate and compare, from an environmental point of view, different supply chain scenarios which include the re-use of recovered materials as elements of the whole process. The tool identifies the most sustainable routes and evaluates the impacts in terms of CO_2 and main pollutants emissions and travel time needed to connect all the stakeholders involved in the chain.

The Logistic Platform has been developed according to the needs of the business models, for example fostering uptake of recovered materials in products, improvement to the end-of-life product logistics and assessment of the supply chain environmental benefits, which are validated in the scope of the project through the demonstrations in the four different use cases.

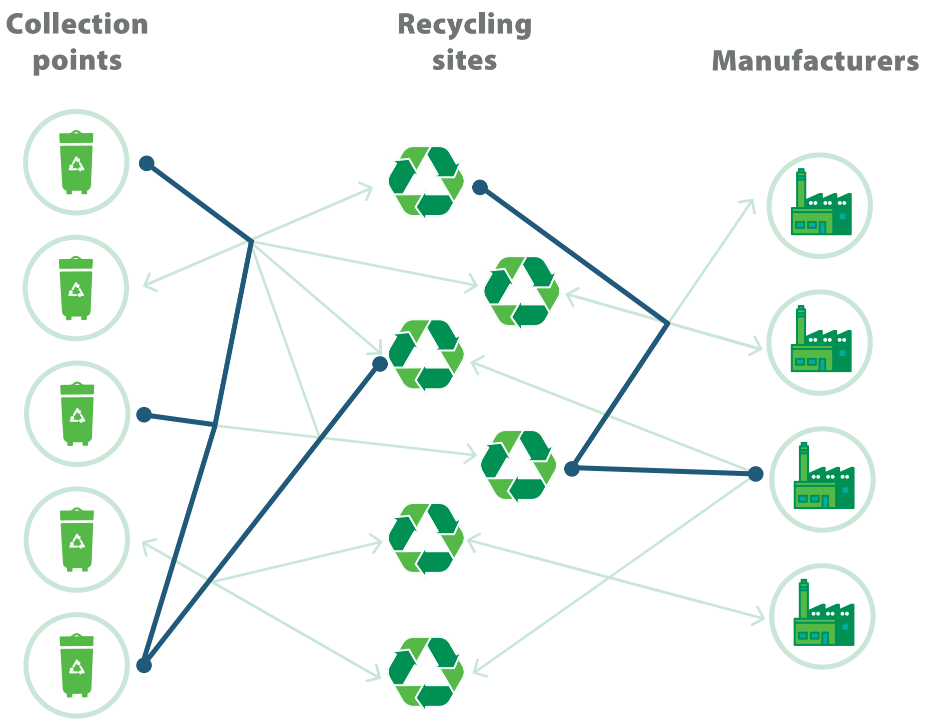

Figure 5 *Optimised logistics*

The Logistic Platform can also work as a stand-alone platform or as integration of the overall ICT platform developed in the scope of C-SERVEES project getting data directly from the other tools, especially the C-SERVEES Information Exchange Platform.

The Information Exchange Platform, helps stakeholders, such as manufacturers and end users, to connect with each other and share all the interesting resources needed to perform the optimum recovery and reconditioning processes.

With the different functionalities offered by the system, users can discover which companies are involved in CE processes, start new relationships, consult all available information such as documents, files, step-by-step guides, etc. and have conversations within the platform, adding new useful information to it.

The Information Exchange Platform offers the following functionalities:

- Discover and connect with different companies to start a new relationship.
- Upload and download useful information such as guides, manuals, reports etc.
- Create and read step-by-step guides related to recovery and reconditioning processes.
- Maintain conversations within the platform on the forum section.
- Integrate the use of the blockchain system and the Logistic Platform.

By integrating the three ICT tools developed in C-SERVEES, users can connect information between the Information Exchange Platform, the Logistic Platform and the blockchain based system, spreading the relevant data through all three tools.

3.3 Method

The minimum viable product consists of a **blockchain-based communication protocol** that allows the communication of sensitive material data along the supply chain in order to provide the material information that is necessary to close the loop of a circular economy.

1) The digital twin system is a system used to certify commitments on sustainable production processes, recycled material use, and materials contained in a product. This system allows producers to prove their commitments and market their products as sustainable. The system allows the identification of products and materials and traceability of products and materials.

2) Smart Questioning technology is a patent-pending technology which builds on the digital twin system. The technology allows the communication about material properties of products while privacy and data security are assured. This system is implemented on a new web application fulfilling all data security and encryption requirements.

The main core of the Logistic Platform is the **Best Routing Algorithm** developed to support the user in the identification of the most sustainable routes and combination of vehicles per scenario. The algorithm combines two factors:

- The optimization of route planning by defining the best sequence of nodes of the supply chain and the shortest path between two nodes of the chain; and
- The identification of the appropriate number of trucks according to loading constraints but also aiming at minimising the total driving distance covered by trucks to connect all the stakeholders involved.

Then, with reference to the identified routes, the tool evaluates the CO2 and the main pollutants' emissions (NOx and PM10), implementing an environmental assessment methodology based on version 5.2.2. of the COPERT, an EU standard vehicle emissions calculator.

As for the **Information Exchange Platform**, its usefulness lies in the establishment of a social framework that allows communication and transmission of information among partners. This is achieved through the different sections of the tool but mainly because of the forum system that allows interaction between users.

The Information Exchange Platform allows interaction between all C-SERVEES ICT tools because it allows for a retrieval of the information of the products hosted in the blockchain-based system to subsequently propagate them into the logistics platform to calculate the best possible route for the selected products.

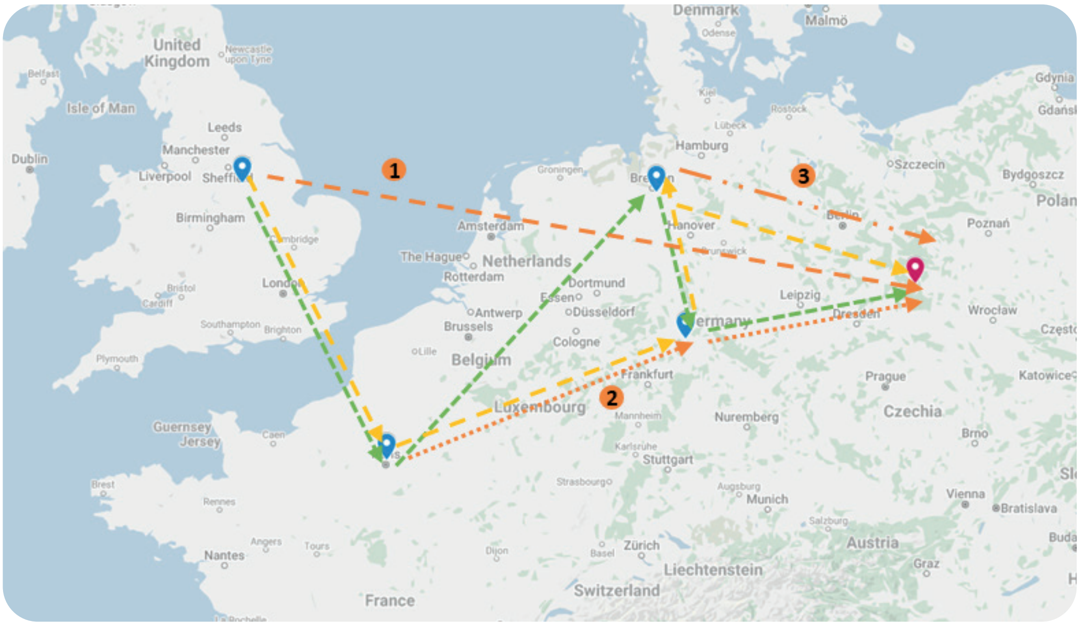

Figure 6 *Example of optimised logistics*

3.4 Results

C-SERVEES has shown that the blockchain-based system is able to address the many challenges of the CE. Recent regulations such as the green deal and national mechanisms, for example in Germany, have confirmed the increasing attention of governments for supply chain transparency.

While there are different approaches to material data sharing in supply chains, the project has revealed that it is beneficial for manufacturers to engage in such activities at least partially.

After a testing phase of the algorithm, the Logistic Platform was used within the Lexmark demonstration on printers and within the Arçelik demonstration on TVs and washing machines. In none of the demonstration cases a baseline was available since both companies are still not implementing the reverse logistics for these products which are not returned to the production site. However, the industrial partners were interested in simulating this scenario to identify a possible logistic chain and evaluate its environmental impact. In both cases the savings made through the best routing, in terms of driving distance and emissions, compared with the worst (no multi-path route) are about 30-40%.

Similar results have been obtained with respect to the Information Exchange Platform, which has been used in the demo phase by Lexmark and Arçelik with interesting findings but has not yet been implemented in the companies' work dynamics.

3.5 Future work

Many C-SERVEES partners are involved in or closely following the work of standardisation agencies and stakeholder engagement platforms towards standardisation of data formats.

The Logistic Platform is completely tailored to the C-SERVEES project information and data made available in the project, but the algorithm, the core of the tool, could also be applied as the main element of a stand-alone platform to support companies in optimizing the transport routes to collect products/materials as well as to distribute their products. In this case, specific developments and customisations may be needed to adapt the Logistic Platform to the needs of the customer companies, but the core algorithm could be integrated to achieve the companies' targets and to increase sustainable logistics concepts based on transport planning.

In its individual use, the Information Exchange Platform can be replicated in other environments and sectors where it can enhance and enrich the social component of the processes being addressed.

4 Demonstrations

4.1 Background

Four demonstrations were undertaken in C-SERVEES, each focussing on one of the four products. Central to these demonstrations were the original equipment manufacturers (OEMs) involved in the project, ADVA, Arçelik and Lexmark. The demonstrations were aimed at testing and validating the new CEBMs by integrating four basic pillars: eco-design, eco-leasing, improved WEEE management, and ICT services. In addition, the testing of end-users' acceptance was addressed via surveys and living labs.

Specific CE actions were selected for each demonstration stage based on the outcomes of the four product specific CEBMs. Many of them were supported by the use of the C-SERVEES ICT systems. These CE actions are classified into the three main stages of the life cycle: design and production, distribution and use, and end-of-life. The detailed description of the activities and results can be found in the project reports section of the C-SERVEES website. See: D4.2. Demonstration of design & production phase for target products; D4.3. Demonstration of distribution & use phase for target products; and D4.4. Demonstration of end-of-life phase for target products.

4.2 Method

The demonstrations covered the whole life cycle of the products, from the design phase to the treatment of the waste generated when the product entered the waste stream. The aim was to identify potential areas for improving circularity derived from the exploration of the product specific CEBMs which were translated into specific CE actions to be implemented in each demonstrator.

ADVA, Arçelik and Lexmark, have adopted business-oriented perspectives in order to exploit the project's results. Customer feedback has been gathered through online questionnaires, in-depth interviews and living labs to understand attitudes, expectations and experiences of customers and end-users related to eco-design, eco-leasing, reuse and refurbishment, and purchasing second-hand products. The insights collected were used to define and refine business case scenarios for future exploitation.

The main eco-innovative solutions and services explored in the demonstrations were:
- Eco-design
- Eco-leasing
- WEEE re-use and remanufacturing
- WEEE recycling
- ICT services

Although all of them were explored in each demonstration, the emphasis was different depending on the OEMs strategic circularity goals, perspective and type of product.

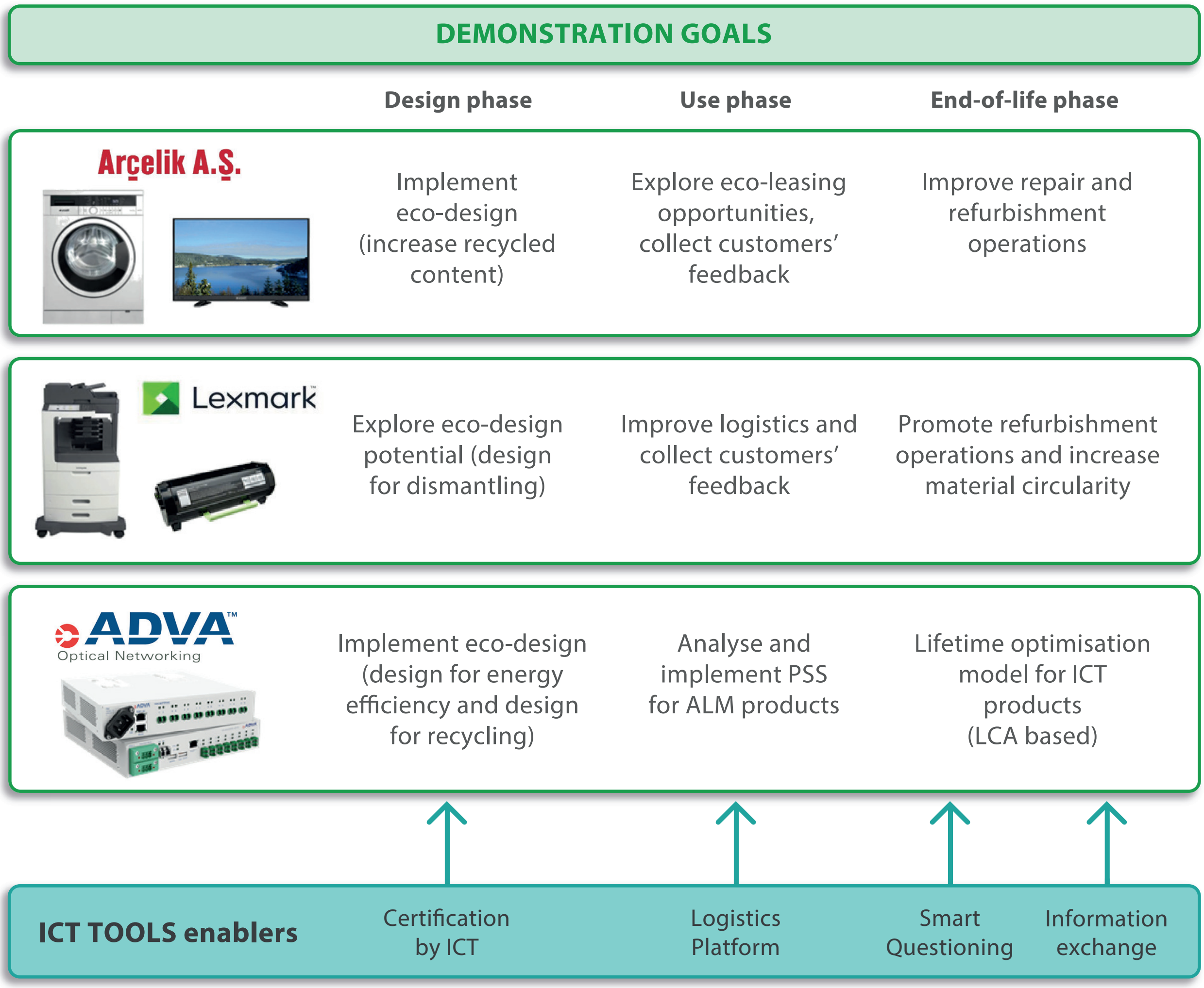

Figure 7 *The eco-innovative solutions applied to each product in the demonstrations*

Eco-design was applied to the washing machines and TVs with a focus on low-impact materials, whereas in the ALM the focus was on energy efficiency and longevity. In both cases, new eco-designed products were produced during the demonstration. In the printer and toner cartridges demonstration, eco-design was explored focusing on the potential for easier disassembly and recycling of components, but these proposals were not implemented in new products during the demonstration. Instead, the printer and toner cartridges demonstration focused on different aspects of reuse and remanufacturing, exploring ways of enhancing the refurbishment operations for printers and making this business line more relevant in compliance with circular economy principles.

Eco-leasing was analysed in the most in-depth way in the ALM demonstration, where different PSS were considered for the ALM and in the washing machine and TV demonstrations, as a potential new business line to be adopted for B2B customers. The involvement of a non-governmental organisation (NGO) authorised to perform preparation for reuse operations creates findings that can be replicated across Europe for the Arçelik brands, e.g. the reuse of currently discarded EEE products in a social economy environment.

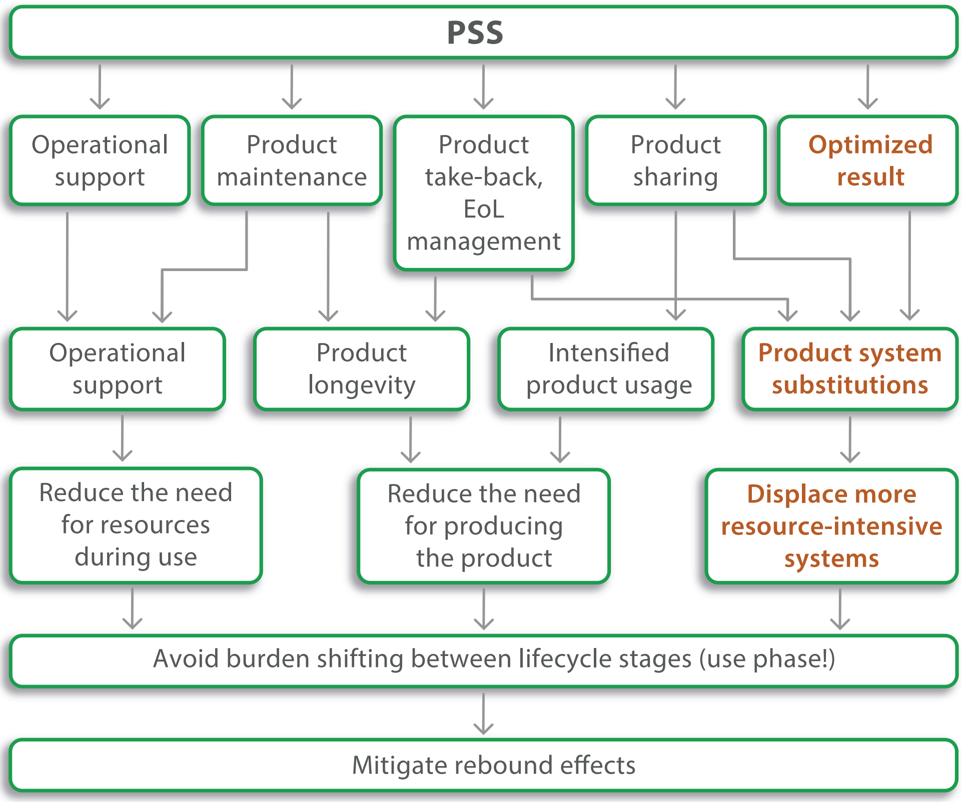

Figure 8 *Exploration of PSS in C-SERVEES*

Improved recycling and dismantling were investigated for all the target products, resulting in new dismantling protocols, new eco-design proposals and potential new business lines to be considered for the recovery of spare parts and components. Closed loop recycling has been demonstrated as well, with the potential to become a viable alternative for washing machines and TVs.

Product lifetime optimisation thoroughly analysed in the ALM demonstration, resulted in the proposal of a new LCA-based indicator to calculate optimum lifetime, based on resulting Global Warming Potential (GWP) ratios.

The use of ICT tools as support to the CEBM activities and goals was demonstrated through the testing of the integrated C-SERVEES ICT platform across the four demonstrators, i.e. certification of recycled content by ICT, Smart Questioning, reverse logistics optimisation and secure information exchange among the various actors in the supply chain.

4.3 Results

The **washing machine and TV set demonstrators**, led by Arçelik, focused on developing eco-designed products and demonstrating the viability of eco-leasing, re-use and remanufacturing through the development of new business lines that could be implemented in Europe for Arçelik brands in collaboration with other actors in the supply chain. In the C-SERVEES project, the basis of the collaboration was offered by reuse NGO, Emaús, which took care of giving a second life to washing machines and TVs with a focus on the social and solidarity economy. This complemented the B2B leasing/renting model examined by Arçelik during the project, allowing those products to be collected, repaired and reused after the leasing period. Collaboration with recyclers Indumetal and Greentronics resulted in the improvement of disassembly operations and an analysis of the potential to recover valuable materials and spare parts from end-of-life products. The potential to use 3D printing technology for customisation purposes and production of spare parts was explored with Particula for both washing machines and TV sets, highlighting several difficulties in creating viable parts.

Image 1 *C-SERVEES washing machines in situ*

The **printer and toner cartridges demonstrator**, led by Lexmark, has focused on the analysis of levers and enablers to expand the printer refurbishment business within the Managed Print Service (MPS) offered by the company. The two main issues identified in the demonstration as critical for the new CEBM (cost and customer acceptance) were addressed in depth. Furthermore, research in collaboration with recyclers allowed the viability of a new business line to recover spare parts and to reuse secondary raw materials from end-of-life printers and toner cartridges to be determined. Needs and expectations from customers were analysed through targeted surveys and live testing with refurbished printers. Finally, 3D printing has proved to be interesting for certain non-functional parts.

Image 2 *3D printed TV stand*

Image 3 *Refurbished printer in situ*

The **ALM demonstrator**, led by ADVA, initially focused on the development of eco-designed passive sensors for the ALM system for increased energy efficiency and longevity. The transition to a PSS for the ALM products was then explored and tested with a selected customer. ADVA subsequently validated an LCA-based lifetime optimisation model for ICT products, generalised it to other products and presented a useful tool for determining the most sustainable lifetime period depending on the use model of a given EEE product. This was complemented by a PSS assessment model since different PSS may apply depending on the influence of the use phase. The outcome of this model provides useful guidelines for EEE manufacturers, to shift their efforts to different eco-design approaches, and to policy makers, to consider different recommendations for circular economy depending on the type of EEE and the expected usage time. In collaboration with recyclers, guidelines for disassembly and eco-design measures for ICT products have been developed.

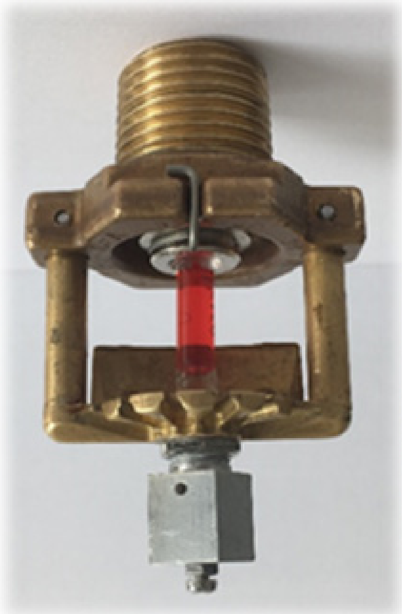

Image 4 *ALM sprinkler sensor*

4.4 Recommendations

- There is a need to analyse EEE regarding their CE characteristics and limitations before making recommendations for their reuse/replacement/recycling. Generic, across-the-board recommendations are not desirable.

- Results from in depth PSS analysis of ICT equipment show that not all PSS make sense. Material recovery yield at end-of-life is a determining factor when choosing a PSS. If this yield is limited through, for example, obsolescence, the PSS do not differ too much. If meaningful services can be offered, e.g. operating the equipment, leasing does seem to make sense.

- ICT solutions offer the possibility to provide useful information via QR codes, for example the percentage of recycled material used in the product. This can help communicate a company's sustainability actions to their clients.

- ICT solutions also enhance the repair and refurbishment operations, increasing the recovery of products. A QR code can be used on specific components with information about the material composition, which is useful at the repair/dismantling/recycling stage.

- In the business-as-usual scenario, recyclers do not receive WEEE in good condition. This reduces the potential to recover spare parts. Therefore, from a circularity perspective, it makes more sense for repair companies to have special operations to work on the recovery of components before the product becomes waste.

- A digital dismantling manual would help recyclers be more efficient while dismantling printers and recovering parts to be sold to OEMs; this was proved by the demonstration to be cost efficient. Assuming the industry moves forward with QR code usage, dismantling instructions could be linked to QR codes on the product.

- Reverse logistics is shown as a major challenge today: how to locate used products and bring them back to a refurbishment plant at a competitive cost, given that the client expects the refurbished product's price to be significantly lower than a brand-new product is key.

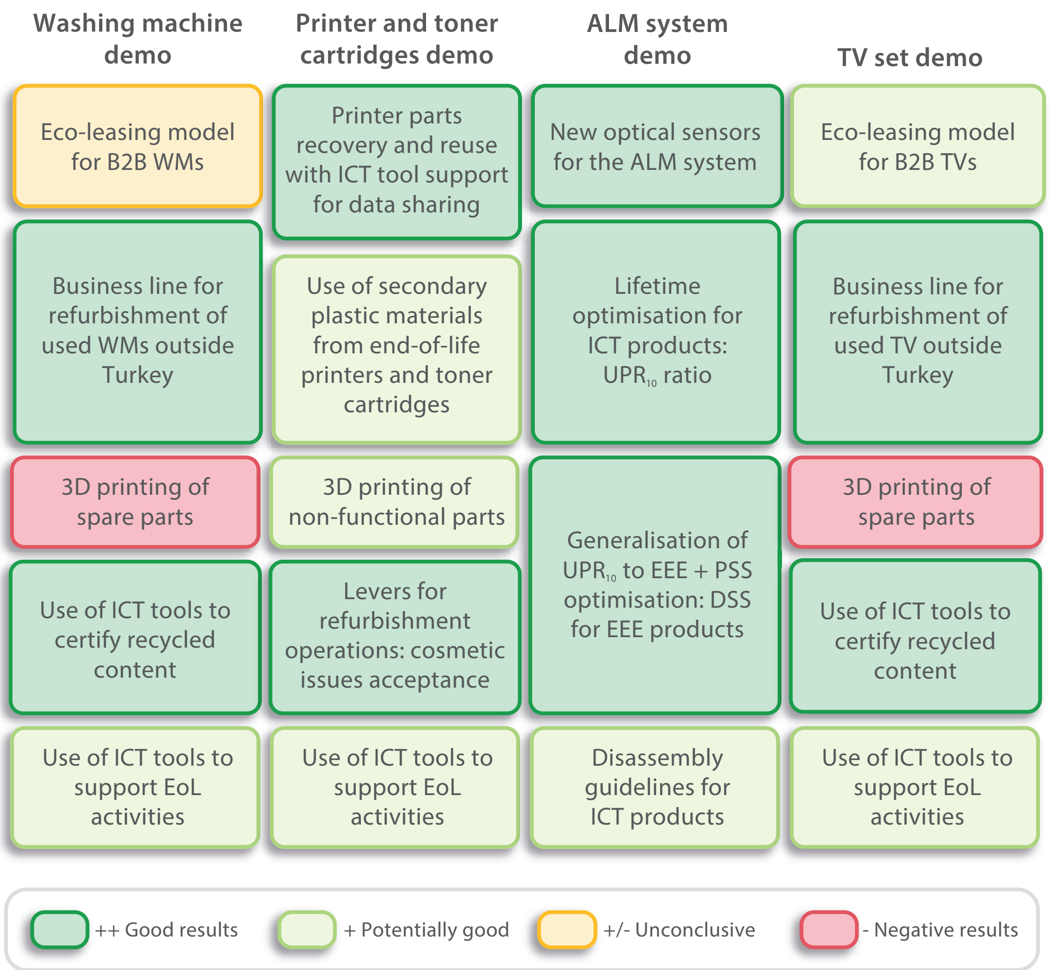

Figure 9 *The main aspects explored in the demonstrations, classified according to the potential for future exploitation*

Note to Figure 9: *UPR_{10} is the ratio of 10 years use-phase Global Warming Potential and the production GWP according to Life Cycle Analysis methodology.*

5 Sustainability Analysis

5.1 Background

The sustainability analysis was used to assess the validity the new CEBMs' sustainability. The evaluation of the proposed solutions was conducted by applying life cycle sustainability assessment (LCSA) to the demonstrations to measure their performance in relation to the three pillars of sustainability: 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: the linear or conventional option and the circular or new economy model option.

This assessment was completed with a socio-cultural acceptance and public perception analysis which was carried out to analyse how end users and society are aware of and perceive the problems associated with WEEE and its management, as well as their acceptance of the new circular products and services provided.

5.2 Method

The environmental impacts were determined using the LCA methodology according to ISO standards 14040/14044. The assessment comprised the whole life cycle of the products. The lifecycle inventory was then converted into environmental impacts using ReCiPe, a life cycle impact assessment method. Additionally, the Material Circularity Indicator (MCI) was determined to assess the circularity of the current product and business models.

The economic costs associated with the complete life cycle of the four target products, including internal cost (related to manufacturing, use and end of life), as well as environmental externalities were assessed using the LCC methodology.

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 allowed for the calculation of social impacts. A cradle-to-gate assessment was applied: the scope of the social assessment covers from the extraction and processing of raw materials to the delivery of the finished product at the factory gate. The database 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).

Finally, a social and cultural acceptance analysis was conducted via an anonymous survey translated into different languages, launched through different channels to different stakeholders and designed using the results of a preliminary study.

5.3 Results

Washing machine

LCA: Environmental and circularity enhancement of the washing machine is achieved with recycled materials for the inner door, the detergent box and the tub. In addition, there was a reduction in the mass of the tub, the inner cover and the detergent box. These improvements reduced the environmental impact in almost all impact categories to a maximum of 0.3% and increased the MCI by 1.7%, from 0.249 to 0.253.

LCC: Recycled materials and mass reduction introduced in the C-SERVEES washing machine reduced the total cost by 0.01%.

S-LCA: The C-SERVEES washing machine and the reference washing machine have the same social impact, so the reduction of social impacts is not significant. The country with by far the largest contribution is Turkey, which accounts for about 90% of total washing machine production costs.

Printer

LCA: Circularity and environmental enhancement of the laser printer is achieved with remanufacturing. The environmental impact is reduced during manufacturing of components, together with transport of components and maintenance (replacements and transport). To achieve this improvement there is an increase in end-of-life impact and a loss of recycling benefits. However, the improvement from remanufacturing is far greater than these losses. Even considering all spare parts and consumables, the carbon footprint improvement is 3.3%. If consumables and energy during the use phase are not included, the carbon footprint and the average of all impact categories improve by 8%. The MCI improves by 12.3%, from 0.48 to 0.55.

LCC: Reusing components for remanufacturing reduces the external cost of the production process by 8.4%, although this requires increasing the cost of the end-of-life phase by 16.9%, leaving the total reduction at 0.2%.

S-LCA: 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

LCA: Environmental impacts are significantly improved thanks to the introduction of ICT that have improved the maintenance of the telecom equipment increasing the lifetime from 8 to 15 years and making feasible the 10% reuse of the central ALM unit together with the use of recycled material for sensors. The environmental improvement is an average of 40% across all impact categories, if only the ALM product is considered in the LCA, or 20%, if electricity during the use phase is also considered. The MCI improves by 73%, from 0.41 to 0.71.

LCC: The introduction of ICT has improved the maintenance of the telecom equipment increasing the lifetime from 8 to 15 years and making feasible the 10% reuse of the central ALM unit. Increasing the lifetime and reusing parts of product modules for remanufacturing reduces all life cycle cost categories by an average of 42%.

S-LCA: Social impacts are reduced by 47% while the production cost is similar. Germany and China are the countries with the highest social impacts for all social categories. Despite China representing only 6.5% of total production costs, the social impacts there cover between 30% and 47% of the total ALM product impacts depending on the social category assessed. In contrast, the case of Germany is notable because 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

LCA: Re-manufacturing TV sets positively affects environmental impacts. An average of 38% across all impact categories if only the TV is considered in the LCA, or 23%, if electricity during the use phase is also considered. Remanufacturing and recycled materials reduce virgin feedstock by 2.79 kg for one TV, thus the MCI improves by 52%.

LCC: Components reused for remanufacturing reduces the external cost of the production process by 39% and the end-of-life cost by 5.6%. Therefore, total costs are reduced by 3.7%.

S-LCA: Components reuse for remanufacturing reduces the social impact of the production process by between 7% and 20%. Of importance to the social impact improvement is the reduction of new components supplied from China due to the remanufacturing.

A significant participation (95% of respondents), balanced in terms of gender and family size, but not in terms of age and education level, was considered in defining the conclusions. The respondents mostly agree that linear business must become circular.

The responses allow to identify advantages associated with re-used and refurbished products or why aspects of a purchase decision are more important for them. For example, price has a strong influence in the purchase decision and could limit the popularity of more expensive products or services from CEBMs.

5.4 Recommendations

In the life cycle of a product, the phase of the product with the greatest impact can vary; in some cases it is the design phase, and in others the use phase or the end-of-life phase. One recommendation is that manufacturers should identify the phase that has the greatest impact in the life cycle of the product and focus the main effort there.

At European level, a study should be undertaken to assess which phase of the lifecycle of different types of EEE is most relevant.

Policymakers should consider the findings of the social-cultural acceptance analysis. A product's eco-design or the various models such as leasing or pay per use may give rise to bigger acceptance among users, but in some cases also higher maintenance and repair costs.

6 Implementation of Circular Economy Business Models (CEBMs)

6.1 Background

The main goal of this final part of the project was to reinforce the implementation of each CEBM. The project aimed to review and identify the most promising CEBM strategies and actions for each product and provide guidelines for increasing the speed and effectiveness of future testing and implementation activities.

Relying on the CEBM framework developed and defined in the project and considering the evidence of the demonstration activities and of the analysis carried in other parts of the research, this work provided support to industrial partners in the follow up of the implementation activities, by finalising the CEBM design for each product and setting up the roadmap for future testing and improvement.

This work also aims to provide input to future projects undertaken by consortium members, the EU or other organisations which focus on the implementation of CEBMs.

6.2 Method

Two main approaches were discussed: quantitative and qualitative. This second option was selected due to confidentiality issues raised by the partners around sensitive data such as revenues and cost, and the uncertainties in quantifying market size and volumes. Therefore, for each of the four products the main assessment and research areas were:

Reflection on the results of demonstration activities.

Value Chain Map: overview of the current state of material and service flows, with an emphasis on the reverse logistics for EoL products.

Ideal State Design: imagining what could be the ideal state of CEBM. This phase is intended to generate the ideal concepts that will guide the design of the future state.

Future state: synthesising the CEBMs for future test and development iterations.

Cost and revenue drivers' assessment: a qualitative evaluation of the main costs and revenues associated with the future state of the CEBM

SWOT analysis.

Road Map for implementation.

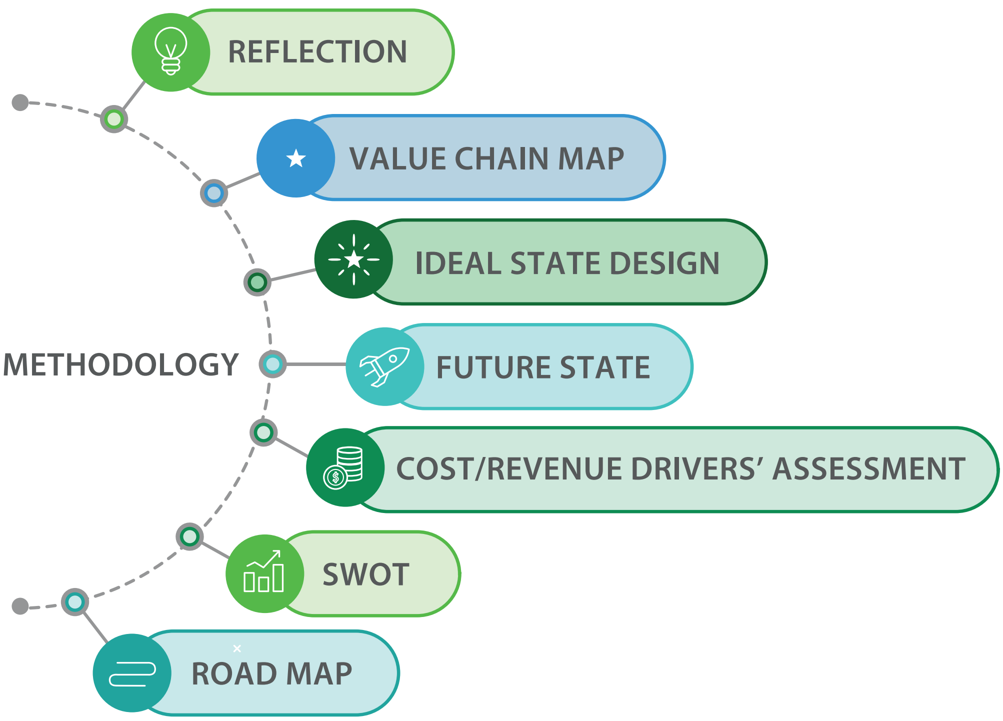

Figure 10 *Assessment and research areas for the four products*

This methodology has been designed to raise awareness and support industrial partners in implementing CEBMs. The main stages were:

- Review of C-SERVEES research
- Review of literature on Business Model Innovation
- Planning and execution of the working sessions with the teams
- Synthesis of results, feedback collection and finalisation.

6.3 Results

The work with the industrial partners envisioned a future for CEBMs with the following main elements of value creation, delivery and capture:

PSS - Product Service System: product ownership will move from customers to producers. Both producers and customers will be able to analyse product usage and performance through advanced analytics that could also show other CE indicators such as energy consumption and carbon footprint. Alternative profit models such as subscription or pay-per-use services will be developed and implemented (i.e. PaaS – Product as a Service).

New value-added services will be available for the customers such as 'easy' and digitalised product return, that will give information on reverse logistics and refurbishment. Other services (new business opportunities) could be related to maintenance, monitoring, customer training, user's behaviour analysis and improvements, materials management, etc.

Optimized reverse logistics: consolidated shipment of EoL products/components, optimisation of the logistics network, resources shared with other organizations (warehouse, trucks, logistics employees, etc.), collaboration with partners that specialise in the collection and sorting of all types of EEE, in order to guarantee that 100% of EoL products can be properly managed: collected, analysed, repaired, reused (components), refurbished, recycled (only the fraction of materials that can't be treated in the previous phases).

Based on the business cases and business models developed for the C-SERVEES project, we can synthesise the main factors that can impact CEBMs implementation at 3 levels (see Figure 11):

- Company factors (related to strategy, organization, and processes)
- ICT tools (as enablers)
- Policy (as an enabler)

	Strategy	Organisation	Organisation
Company	• CE objectives in company strategy • Allocated budget for CE • Top management commitment • Customer involvement and education in CE	• Dedicated teams (direct report to CEO) • Training and upskilling workforce • Incentives aligned all over the organisation (function/ unit) • KPI and clear measures of the benefits • Communication to all the stakeholders	• Eco Design principles implementation (materials and assembly) • PSS improvements: PaaS and new Value-Added Services • Extension/Optimisation of Reverse Logistics network • EoL product management optimisation: refurbishments, repair – reuse –recycle • KEY PARTNERSHIP: dealers/ distributors, logistic operators, collection centres, recyclers • Benchmarking with other competitors/industries on CE

Tools (ICT)	• Digital Product Passport (DPP)
	• Network infrastructure of connected products
	• Analytics (AI) for liffetime extention/optimisation
	• Logistics network optimisation tools
	• Information sharing, communication, and training tools
	  – Reverse logistic/supply chain visibility/tracking
	  – Product information (i.e. composition)
	  – Instructions and training tools for operators
	• ICT tool for customer EoL product return		

Policy	• Eliminating the limit of using 2nd life components in new products • Mandatory harmonised targets for public purchasing at EU level: green public procurement guidelines exist (different application in any nation) but are not completely effective • Tender model more focused on environmental and social impact (move from a nice to have to a mandatory requirement) • Public incentives to sell and promote refurbished products (i.e. elimination of VAT) • Commen EU durability index • Clear distinction between waste and EoL products -> tahat are resources		

Figure 11 *Main factors for an effective CEBMs implementation in E&E industry*

With several limitations, that should be addressed during future implementation of C-SERVEES outputs, we propose an approach that can be taken as the basis for future developments of CEBMs in E&E industry.

7 Policy Recommendations

7.1 Background

Current legislation, regulation and policy were examined to identify and propose potential measures to improve policy related to the developed products and services in the E&E sector.

7.2 Methodology

The steps taken to evaluate the gaps were as follows:

1. Analysis of policy framework: desk research, interlinkages with other C-SERVEES activities and involvement of Consortium partners.

2. Analysis of non-technical barriers: online interviews with EEE manufacturers and recyclers of the target products.

3. Stakeholder consultation: internal (consortium partners) and external consultation (Advisory Board members, members of associations participating in waste management standardisation tables, etc.).

4. Analysis of findings & development of policy recommendations: analysis of the above steps and inclusion of recommendations from available public documents.

7.3 Results

An overview of the current EU legislative framework in the E&E sector was compiled (see D6.2 Position paper with recommendations for policy makers).

In addition, a series of policy recommendations to overcome legislative barriers were made:

- **Legislators** shall provide financial, informational and regulatory incentives to stimulate the repair, re-use and remanufacture of products.

- The **EU** and **Member States** shall develop guidelines and/or public campaigns targeting the main actors to increase awareness, understanding and compliance with the regulatory framework.

- The **European Commission**, along with the **Member States**, shall engage the final users in awareness-raising programmes, improving accurate identification of materials and their proper disposal into separate collection systems.

- The **European Commission**, together with **policy makers**, shall differentiate the regulations according to the product specifics, preserve the requirements of CE at EU-wide level, in order to avoid market fragmentation resulting from different national laws and discrimination among product categories.

- The cooperation of the **whole value chain** with **national and local authorities** across Europe is fundamental to achieve recycled content targets.

- **Manufacturers** shall analyse the impacts of their products, according to the LCA-based method, for a decision-making guide for CE. From the policy standpoint, LCA studies should be required as an element of public procurement practices or invitations to EU project tenders.

- **Public authorities** should express recommendations, via procurement policies, to promote the use of products with a higher content of recycled plastic.

- **Manufacturers** shall indicate, through the application of a standard, the grade of recycled material that they require from their component suppliers. The term "recycled content" does not suffice to incite the suppliers of recycled materials (recyclers) to meet appliance manufacturers' demand, because it is insufficiently specific. A specific grade will encourage recyclers to produce recycled materials that manufacturers actually require in producing their products i.e. to allow the recyclers to anticipate and accommodate demand. The grades of recycled material could be developed by the R&D team of the manufacturer company or by Standards Bodies such as CENELEC, one of the three EU standardisation bodies, with the active support of producers.

- **Technology developers** shall provide technical and technological recommendations regarding standardisation, normalisation and obsolescence of equipment and regarding instruction manuals that enable and facilitate maintenance and repair, technical data sheets, availability of spare parts, languages of documentation, etc.

- **Policy makers** shall consider the real needs of all stakeholders while updating the framework below:
  - Limit values in **REACH Directive**, the **CMRT** or the **SVHC** list.
  - **WEEE Directive** to better address competencies and responsibilities of stakeholders. Most Member States invest producers with the responsibility to meet collection targets, even though they do not even possess full access to all the WEEE at its end-of-life cycle.
  - **POPs Regulation** may turn into a major obstacle, especially in the recycling of plastic waste. For example, the introduction of lower threshold for some substances (like PBDE) can make it very difficult to recycle this waste stream.
  - Strong restriction foreseen from the revision of the **Waste Shipment Regulation** regarding the export of waste from the EU (cross-border movement), without distinction between proper treated waste and untreated waste, can hamper the export of waste needed for the recovery of CRM.

8 Conclusion

After more than four years, the C-SERVEES project has come to an end, and during this time it has given the consortium the opportunity to think about all the circular solutions that are currently offered in the market, how many are applied, if something more could be done in the EEE sector and how we could improve the circular actions of the end-user.

This report presented the project results and how the business models can be applied in practice through testing them on the products of ADVA, Arçelik and Lexmark.

The project has also developed ICT tools that support and enhance the CEBMs. The ICT platform, of interest to policymakers, allows for bidirectionality, information about traceability, product composition and characteristics, development of indicators, modelling, citizen science, user habits, etc. This is based on a user profile that can be used for distribution, sizing and design of e-waste management facilities, logistics, etc.

There are still challenges ahead. All actors in the value chain need to be connected with each other and interventions are required concerning user habits, the design of products, eco-leasing, pay per use, re-use, remanufacturing, repair, refurbishment, recycling, administration, finance, regulation, collection, separation, sorting, distribution and commerce; and all of these right across Europe. The C-SERVEES project presents its results in a manner that allows implementation and further research to be undertaken to enable the use of CEBMs, based on those developed in the project, in the future.

Annex 1 – Consortium Members

ADVA
ADVA Optical Networking is developing and producing new technologies for tomorrow's telecommunications networks. Our intelligent hardware, software and services have been deployed by several hundred service providers / network operators and thousands of enterprises worldwide. Over the past 20+ years, our innovative connectivity solutions, based on Wavelength- Division Multiplexing (WDM) transport, Ethernet aggregation and demarcation, synchronization, encryption and monitoring equipment and the related management, control-plane and SDN software, have helped to drive our customers' networks forward.

AIMPLAS
AIMPLAS' fields of work are related to technological research and development on thermoplastic and thermosetting plastic materials & products, its transformation processes and their recyclability and sustainability. AIMPLAS generates new knowledge and technologies that can be transferred to companies in order to help them to increase their effectiveness and competitiveness.

Arçelik
Arçelik acknowledges that sustainable achievement is not possible without investment in R&D. Hence, Arçelik is strongly investing in R&D; it has 10 R&D centres with over 1000 personnel and fully equipped test laboratories, and is Turkey's leading producer of technology and patents. Arçelik owns more than 1/3 of the patents produced in Turkey and it is the only Turkish company in the World International Property Organisation's listing of the top 500 patent applicants.

Circularise
We already have the technology to recycle, but there is no efficient way of identifying and sorting waste streams. Our current recycling efforts do turn scrap into new materials, but these are of a lower quality than the input. We cannot use the secondary raw materials for the same purposes as the original. It is our goal to overcome the communication barrier that is limiting current and future progress towards a sustainable economic model: the circular economy.

Emaús
Emaús is an organization with over 30 years of experience in Spain, working already in Pais Vasco, Asturias and Galicia. Its mission is to promote and accompany transformation processes, individual or collective, in the social, economic and environmental fields. The organization is committed to improving the living conditions of people with risk of exclusion. Emaús works with social innovation.

Erion Compliance Organization
Erion is the leading Italian Producer Responsibility Organisation (PRO) for the management of waste associated with electronic products and the exploitation of the secondary raw materials within it. Born from the experiences of Ecodom and Remedia, Erion is the strategic evolution of both Compliance Schemes in terms of operational structure, services dedicated to its associated Producers and commitment to the environment, the circular economy, research and technological innovation.

GAIKER
GAIKER Technological Centre, located in the Technological Park of Biscay (Spain), is devoted to the up-take of own knowledge and to the development of new technologies that are later transferred to customers coming from sectors such as the Pharmaceutical Industry, Chemical Industry, Human and Animal Health, Engineering and Consultancy Firms, Public administrations, Automotive Industries, Construction, Packing and Packaging, and Home Appliances, amongst others.

Greentronics
We are experts in the collection, treatment, recycling and reuse of waste electrical and electronic equipment in Romania. The company offers complete and custom tailored to individual needs of each customer. Concern of the management team to significantly reduce the extremely harmful impact of waste electrical and electronic equipment on the environment and human health, is reflected both in our current work, and through company involvement in four major European research projects which have as thematic development of new technologies and exchange of know-how between similar companies in EU countries.

INDUMETAL
Indumetal Recycling S.A. (INDUMETAL) is a specialized industry with an extensive experience in the integral handling of WEEE (Waste Electrical and Electronic Equipment) and complex scrap including: logistic services, on site dismantling of industrial facilities and decontamination and recycling. Once the equipment has been decontaminated, the processes give the company the possibility to obtain a high percentage of materials and useful components for their reincorporation into the market as secondary raw materials.

Lexmark
Lexmark International, Inc. was founded in 1991 and became quickly established as a top global provider of printing solutions. With its global headquarters located in Lexington, Kentucky, Lexmark has a long history of research and development focused on connecting unstructured print and digital information across enterprises with the processes, applications and people that need it most.

Loughborough University
The School of Civil and Building Engineering is one of the largest multi-disciplinary engineering schools in the UK.
According to the latest independent national Research Excellence Framework (REF December 2014), 95% of our research was rated as world-leading or internationally excellent for its influence on society, the economy and policy and it ranked first in the UK in Architecture, Built Environment and Planning in terms of its research environment.

Particula Group
The company wants to imprint change in industrial manufacturing through 3D printing. We believe that 3D printing will change the paradigm of mass-production, bringing it closer to the individual consumer, in such a way as to take us into a more leisure-oriented society. We consider personal creative expression to be a way to the future, unlike any economic theory that, during the last few years, has left us with no space for breathing creativity and inspiring innovation in other types and forms.

PNO INNOVATION S.L.
PNO Innovation SL is the Spanish branch of PNO Innovation, part of the PNO Group, specialised in Innovation Management and funding, providing support services to private and public organizations in Innovation processes, Technology Transfer, IT solutions and funding for research, development and innovation.

Rina Consulting
RINA provides a wide range of engineering services covering the whole project life cycle from feasibility and specialized technical studies to conceptual and detailed design, prototyping and testing, project management, site engineering as well as operation and maintenance management. Innovation is a key element in RINA engineering developments in the Energy, Transport & Infrastructure, Marine and Industry sectors. In the Certification and Regulatory business, RINA has issued more than 36.000

product certificates, delivered more than 28.000 management systems certificates and performed 150.000 laboratory tests.

SAT

SAT was founded in 1996 as a non-profit research and technology-transfer organisation, located in Vienna. The different activities embrace research, development and technology transfer as well as training in resource efficiency with European industry. The organisation serves various small- and medium-sized recycling and re-use companies as well as large enterprises from the electronics sector (e.g., Apple, Continental, Dell, Fujitsu Services, IBM, Lenovo, Mitsubishi, Motorola, Nortel, Philips, Schneider, SEB, Siemens, Sony) in order to reach full legal compliance at minimum cost.

SOLTEL

Soltel IT Software is part of Soltel Group and its main activity is customized software development: web and mobile solutions,workflows design and business processes management (BPM) and enabling technologies for knowledge generation (IoT, data analytics, machine learning and prescriptive systems). It also provides services as software factory, IT service management, testing lab and technical and quality assurance office.

WEEE Forum

The mission of the WEEE Forum is to (i) optimise the operational efficiency of the member organisations' WEEE management systems, while striving for excellence and continuous improvement of their environmental performance, (ii) provide a platform for co-operation at European level and the exchange of best practices, (iii) develop standards and technical specifications to fulfil producer responsibility on behalf of producers, (iv) assist its members in the development of their activities in a sustainable manner within the existing regulatory and legislative framework, (v) create a forum of support and knowledge for our members to make expert and constructive contributions to the general debate on the management of electrical and electronic waste.

Annex 2 – Advisory Board Members

Name	Organisation
Bibiana Ferrari	Relight/TREEE
Christian Hagelüken	Umicore
Colin Fitzpatrick	University of Limerick
Constantin Herrmann	sphera
Robert Pfahl	iNEMI (International Electronics Manufacturing Initiative)
Katrin Müller	Siemens
Filip Geerts	CECIMO (European machine tool industries)
Giorgio Arienti	ERION
Ignacio Calleja	EIT Raw Materials
Kensaku Ishibashi	Panasonic
Nancy Gillis	Green Electronics Council
Osamu Namikawa	Hitachi
Pia Tanskanen	Nokia
Martin Charter	Centre for Sustainable Design, University for the Creative Arts
Margaret Bates	University of Northampton
Yoshinori Kobayashi	Toshiba
Eelco Smit	Philips Domestic Appliances
Simon Murray	Currys plc

PROJECT COORDINATOR:

AIMPLAS
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