D 9.6- Analysis of the framework conditions for innovation

Project acronym:	**ReCiPSS**
Project full title:	**Resource-efficient Circular Product-Service Systems — ReCiPSS**
Grant agreement no.:	**776577-2**
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Reviewed:	**KTH, TUD, FHG**
Approved:	**Cali Nuur**
Document Reference:	**D 9.6**
Dissemination Level:	**PU**
Version:	**V 1**
Date:	**28/01/2021**

This is a draft document and subject to approval for final version. Therefore the information contained herein may change.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776577-2

History of Changes

Version	Date	Modification reason	Modified by
0.1	04.01.2021	Initial Draft	Saman Amir Shadi Shams
0.2	21.01.2021	Quality check	Jan Koller
0.3	22.01.2021	Quality check	Nina Boorsma
0.4	25.01.2021	Quality check	Sayyed Shoaib-ul-hasan
0.5	25.01.2021	Quality check	Niloufar Salehi
1.0	28.01.2021	Final Deliverable Submission	Saman Amir

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List of abbreviations

Abbreviation	*Explanation*
APRA	Automotive Parts Remanufacturers Associations
CBM	Circular Business Models
CE	Circular Economy
EEE	Electrical and Electronic Equipment
ELV	End-of-Life Vehicle
EoL	End-of-Life
EPR	Extended Producer Responsibility
ERN	European Remanufacturing Network
EU	European Union
GPP	Green Public Procurement
IRP	International Resource Panel
OEM	Original Equipment Manufacturer
PRO	Producer Responsibility Organization

1. Executive summary

This report addresses legislative obstacles to innovations that could bring wider societal benefits. As part of this work, an extensive review of the relevant research, directives and white papers, as well as several expert interviews, are conducted to identify the obstacles that seem to be hindering the transition to a Circular Economy in the white goods and automotive industry. In doing so this research has thoroughly analysed 6 highly relevant directives and 5 white papers as well as interviewed 10 experts from these two industries. The report also highlights possible policy adjustments, which are necessary to eliminate these obstacles and thereby, enables the transition to the Circular Economy. These policy adjustments have significant importance for ReCiPSS demonstrators to scale up as well pave the Circular Economy transition path for these two industries and beyond. This work is also considered as the necessary first step to initiate an Innovation Deal. Furthermore, the findings of this research will be a major input to the policy brief that the ReCiPSS project aims to deliver

2. Introduction

Increased consumption, depletion of natural resources and sustainability concerns have challenged the conventional linear model of production, consumption and disposal of products. In this context, Circular Economy (CE) has become one of the most popular topics both in industry and in academia as a solution that can contribute to economic growth and concurrently satisfy sustainability ambitions (Lieder & Rashid, 2016), (Geissdoerfer et al., 2018). Compared to the linear economy, which is based on take-make-dispose, a Circular Economy is a regenerative system based on optimizing resource consumptions and reducing waste.

Transitions from established linear economies to a circular economy will require various reformations on different levels such as business models, supply chains, productions processes and even consumption models (Technopolis Group, 2016) (Ellen MacArthur Foundation, 2017) as well as involvement and collaboration of various public and private sectors (Geng et al., 2012),(Korhonen et al., 2018). In facing these challenges, policies and legislative frameworks in the form of legislations and financial incentives have shown to be crucial in order to create necessary collaborations and economically motivate companies in uncertainties regarding profitability of investments (Fei et al., 2016), (Ghisellini et al., 2016). The European Commission has established a program in 2015 called EU Action Plan for the Circular Economy which aims to cover the entire lifecycle of products including production, consumption and End-of-Life (EoL) of products including policies related to waste and reusing it as raw material with the intention of closing the loop (European Commission, 2015). As a part of the Action Plan, new policies have been issued in 2018 in order to improve waste management practices and increase recycling of different materials to different target levels (European Commission, 2015). However, the impacts and outcomes of such policies and legislations on different industrial sectors may vary and need to be investigated. In this study, the policy and legislative implications in CE transitions in the white goods and automotive industries are investigated.

2.1. Research scope

Policies and legislations have a significant impact in addressing transition challenges and preparing the market for large-scale implementation of CE. They can support the transitions to CE by setting crucial incentives, targets, and motivating investors (De Jesus & Mendonça, 2018; Fei et al., 2016; Ghisellini et al., 2016). Lack of measures and reforms in the current legislation can hinder the adoption of CE. In the context of white goods and automotive industries, the legislative barriers are relatively understudied in literature, and more practical evidence from companies operating in these industries is required to address the impact of policies and legislations on the adoption of CE. Addressing this, the aim of this study is to identify the obstacles, in a legislative context, that hinder the implementation of CE in the two mentioned industries and determine how the adoption of CE can be facilitated through new policies and potential adjustments of existing legislations.

This research focuses on two illustrative cases in the context of CE. The first case is based on transitioning from product sale to service-based business models in the white goods industry. In this transition, the washing machines are offered to customers as services through a pay-per-use model. The machines are then taken back to the manufacturer after the use phase for necessary repairs, refurbishments, or recovery depending on their performance and quality status as well as functionality. The appliances will then be offered to consumers again. The legislative barriers for the first case are investigated in the context of transitions to service-based business models and the return of white goods appliances to the manufacturer. The second case is based on remanufacturing of used automotive parts (cores) in the aftermarket of the automotive industry. In car workshops, faulty automotive parts are replaced with new ones. The used parts (in automotive industry used parts are often addressed as cores) are sent remanufacturing, to bring them in as-new condition for re-sale. The legislative barriers for the second case are investigated in the context of remanufacturing of automotive parts.

2.2. Disclaimer

The work presented in this report is a shorter version of the work that is published as the master's thesis report by Shams (2020). The full report is accessible through the link provided in the footnote below[1].

Furthermore, the original task plan was to file an Expression of Interest (EoI) for two Innovation Deals as a parallel activity to the project. In the automotive industry: the Innovation Deal would address the remanufacturing of parts during the use phase for product life extension, promote approaches that require workshops to propose remanufactured parts, suggest programmes that require government owned vehicles fleets to use remanufactured parts and remove taxes penalizing remanufactured part exchange. In the white goods industry: the Innovation Deal would address the possibility to extend the reparability of appliances and the time requirements for spare part availability. For improvements in informing the consumer decision-making process, a reparability label may be proposed. The consortium had to revisit this task because the opportunity to file an EoI is not currently available. Therefore, the consortium has agreed to do the groundwork essential for signing the Innovation Deals: identify the legislative obstacles and provide policy recommendations to the European Commission that may eventually eliminate these obstacles.

[1] http://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1461354&dswid=611

3. Research review:

3.1. Policy mixes for circular economy

In the context of sustainability policies, a single policy will not be able to address all challenges related to all problem areas and all actors following different goals. Instead, a policy mix is required which takes separate innovation stages, and different barriers and drivers into consideration. Policy mix is defined as a combination of policy instruments where there are a coordination and harmonization between several instruments (Bahn-walkowiak & Wilts, 2017). Rogge & Reichardt (2016) have more specifically defined policy mix as a concept with three building blocks; (1) elements, (2) policy processes and (3) characteristics. Figure 1 shows the building blocks of policy mixes suggested by (Rogge & Reichardt, 2016).

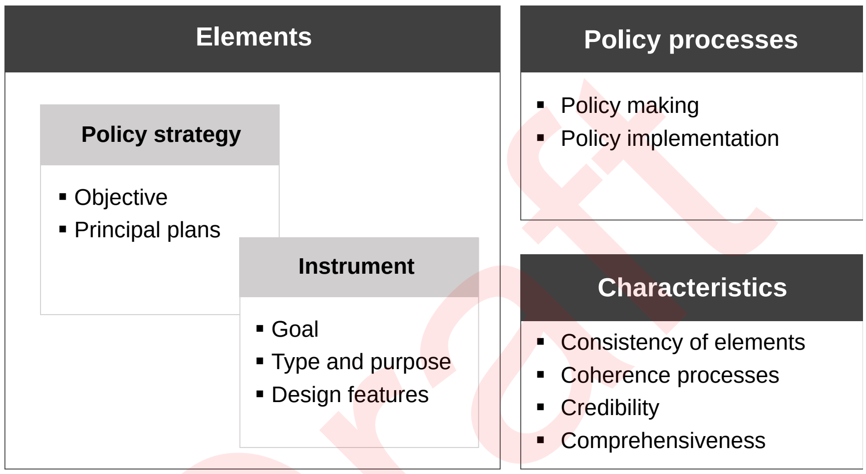

Figure 1. Building blocks of policy mixes, adapted from (Rogge & Reichardt, 2016)

According to the authors, the first building block consists of two elements; policy strategy and policy instruments. The former is associated with goals of the policy and the long-term plans for accomplishing these goals. The latter is the actual tools and techniques that can be used in achieving the goals of the policy. The second building block, policy processes, can influence innovations in sustainability transitions and deals with policy making and policy implementation. Policy making can be defined as finding solutions to societal problems through governments decision making. In sustainability transitions, due to uncertainty, learning and experimenting play important roles in policy making processes. Policy implementation can be defined as putting policy instruments into practice by authorities and relevant actors involved. Finally, the third building block is characteristics of policy mixes. These characteristics are consistency of elements, coherence of processes, credibility and comprehensiveness of policy mixes. The consistency of elements deals with the alignment level between various elements. The coherence of processes is defined as the synergy of policy making processes and policy implementations leading in parallel to the same policy objectives. The credibility of policy mixes relates to how reliable and practical the policies are which can be affected by factors such as political leadership. The last characteristic, the comprehensiveness is associated with the level of completeness of policy mixes, i.e. whether they consider all markets, possible barriers and drivers and failure factors (Rogge & Reichardt, 2016).

In sustainability transitions, determining policy mixes can be more challenging due to the complexity and pace of transformations as well as the new and inexperienced circumstances (Edmondson et al., 2019). The authors argue that there is an interaction between policy mixes and socio-technical changes. In this interaction, policy mixes have an impact on the socio-technical changes in it in terms of resource, interpretative, and institutional effects. Resource effects can influence the direction of transitions and can be related to knowledge and technology that is promoted by policy mix. Interpretative effects occur by providing information and understanding for the actors. Lastly, institutional effects take place through rules and regulations. In response, the socio-technical transformations also have impacts on policy mixes and how they are formed through both positive and negative feedback. Such feedback can be sociotechnical (public and stakeholders), administrative (public body), and fiscal (budgetary and financial) and can influence policy making (Edmondson et al., 2019).

3.2. Role of policy in implementation of circular economy

The transition towards a CE can be seen as a paradigm shift where modifications on different policy levels are necessary (Govindan & Hasanagic, 2018). Consequently, multi-level policy measures including different issues in policy design and policy mixes have been suggested for an effective transition to a CE (Bahn-walkowiak & Wilts, 2017). The policy measures in the context of sustainability are mainly:

- Regulatory instruments (e.g. mandatory targets, standards and certifications)
- Economic instruments (e.g. financial incentives and public procurement)
- Research, development and deployment support measures (e.g. grants for R&D projects)
- Information and education support measures (e.g. advising and training)
- Voluntary measures (e.g. labels and agreements) (Bahn-walkowiak & Wilts, 2017)

The authors highlight that the consistency and coherence of EU sustainability policies need to be improved. They exemplify that the CE policies, such as Circular Economy Action Plan, for the time being, are limited to waste management, and need to be improved by harmonizing strategies, coherent policy processes, consistent, and comprehensive policy mixes. In the following sections policy measures related to the implementation of CE have been reviewed and grouped into the following three themes: Policy measures for reuse of products, policy measures for circular business models and supply chains, and policy measures addressing product lifecycles.

3.2.1. Policy measures for reuse of products

Dominish et al. (2018) have evaluated strategies for optimizing the use of metal resources in production and consumption of consumer goods particularly for vehicles and white goods. According to the authors, the lifetime of home appliances can be extended through repair, reuse, and resale. Policies are mentioned to play an important role in removing obstacles in applying these strategies. These policies should address issues and challenges not only to close the resource loops through recycling, but also recognize the need to slow the resource loops by supporting new business models based on reuse and remanufacturing. Financial incentives and procurement policies are referred to as effective policies (Dominish et al., 2018). Similarly, Ranta et al.(2018) have identified that recycling is considered as the main strategy for CE implementation, while other strategies, such as reuse and remanufacturing, seem to be disregarded. The authors have pointed out that the main barriers for reuse strategies are cultural factors which relate to the customers' perception of reused products. The role of policies and legislation are highlighted in supporting reuse through incentives and supporting programs for return of products to the manufacturers. In order to improve customers' perception of reuse, policies are required to raise awareness through education as well as certifications to ensure sufficient quality of products for reuse. In order to increase the number of products that are reused instead of being recycled, new policies supporting improvement in separation of resource from waste are necessary. This will ensure that the reuse potential of products is recognized and prioritized over recycling (Ranta et al., 2018).

3.2.2. Policy measures for circular business models and supply chains

In adoption of circular business models, Kirchherr et al.(2018) consider cultural factors as the main barrier. According to the authors, prioritizing linear products leads to consumers not being interested in, or aware of, circular products, which in turn encourages manufacturers to produce linear products. It has been suggested that this logical chain can be disrupted through more effort from policymakers by increasing their support for circular business models through for instance reducing Value Added Tax (VAT) on circular products and concurrently lowering subsidies on linear products. Legislative policies are also mentioned to be effective in removing market barriers and in turn increase both companies' and consumers' interest in adopting circular business models. More specifically, Wasserbaur & Sakao (2018), through a systematic literature review, have analyzed the connections between business models and policies. Regulatory policies have been identified as the most, and economic policies as second most researched policies in literature. In addition, a frequent connection between regulatory policies and value propositions has been identified which highlights the significant influence of regulations on how new business models are shaped. According to the authors, economic policies are mainly associated with revenue and cost models, which explains the importance of these policies with regards to taxations, subsidies, and other financial incentives in formation of business models (Wasserbaur & Sakao, 2018).

On the supply chain level, the main drivers in adopting CE are related to climate change and following the waste management policies that have been established as a solution to climate change problems (Govindan & Hasanagic, 2018). The authors have mentioned laws and policies as the most effective practices for transitioning to circular supply chains. It has been pointed out that there is room for improvements in policies and legislation since there is a lack of sufficient financial incentives supporting the adoption of CE in supply chains. Using a more holistic approach, Tura et al. (2019) have systematically categorized the main drivers and barriers in adopting circular business models into environmental, economic, social, institutional, technological, organizational, and supply chain related factors. Lack of consistency in taxations and subsidies are highlighted as the main barriers driven by new regulations resulting in new demands from an institutional perspective.

(Kiefer et al., 2019)), have identified the main internal drivers in transitioning to CE through eco-innovations. The main drivers of CE within organizations are associated with company culture, physical assets, financial resources as well as investments in technologies and sustainable supply chains. According to the authors, these drivers can be addressed by different policies with different levels of intensity for individual organizations. It has been further explained that a joint policy may not be applicable to an entire industry. Acknowledging the differences in industries and firms is important in adoption of CE through policies.

3.2.3. Policy measures addressing product lifecycles

Hartley et al. (2020)) have suggested a set of policies for accelerating the adoption of CE in the EU based on different phases in products' lifecycle, namely (1) production phase, (2) use phase, (3) EoL phase, and (4) product return phase. For the *production* phase, it is recommended to initiate standards on the EU level for supporting circular design of products, which consider reuse, repair, refurbish and remanufacturing of products. In the *use* phase, policies for public procurement are suggested to support circular products. In this way, the role of governments would not only be limited to regulations, but they will also be involved in purchasing and co-production of circular products. In the *EoL* phase, creating financial incentives for producers of circular products is recommended in order to increase their profitability. Reducing VAT on repair and reuse (implemented in Sweden) or increasing the price of newly extracted materials are some examples of such policies. Another recommendation in EoL phase is to improve waste legislations in order to permit cross-border transportation of waste that can be remanufactured or reused. Consequently, the definition of waste itself can also be modified, which helps in recognizing the value and potential of used products for reuse and remanufacturing (Bastein et al., 2013). Establishment of a virtual platform is also suggested in order to facilitate access of producers to information regarding waste transparently. In the *product return* phase, it is recommended to minimize information gaps and increase transparency in material flow through policies and programs e.g. using databases for the return of products. It is also recommended to policymakers to increase awareness of consumers about benefits of circular products through programs and campaigns (Hartley et al., 2020).

Milios (2018) has mapped the current EU policies for sustainability and circularity of material flow to different stages of products lifecycle. The mapping indicates a lack of sufficient policies for production and consumption phases during a product's lifecycle. In this regard, a set of policy mixes are suggested by the author for each phase in order to enhance the implementation of CE in the EU.

In the production and product design phase, durability and repairability, as well as remanufacturing policies, are suggested. In order to increase the durability and repairability of products, it is necessary to ensure that spare parts and information regarding repairs are provided by the producers at reasonable costs. Regarding remanufacturing it is suggested by the author that more clarification and information is required when it comes to remanufactured parts that are put back to the market. The issues become significant in applying the EU policies such as Extended Producer Responsibility (EPR) when the manufacturer or remanufacturer should take responsibility for their products. In the use phase of products lifecycle policies such as Green Public Procurement (GPP) are suggested that are effective in pushing innovative and sustainable solutions. According to the author, GPP is not fully implemented in the EU and can therefore become a mandatory policy for authorities. In EoL phase, it is suggested by Milios (2018) that the current EPR needs to be improved. Currently, the producers pay for collection and treatment costs of the waste of their products based on their market share. It has been further explained that the current EPR may hinder encouraging the producers to improve the design of their products for less waste generation. In addition, many other actors are involved in the processes regarding waste management, which makes it difficult for the manufacturers to take back their products at EoL phase. Therefore, it is suggested to adjust the current EPR so that individual producers will be responsible for their own products only.

To summarise the above discussions, policies play an important role in closing the resource loops and extending the lifetime of products. In this context, the current policies mainly address recycling while reuse and remanufacturing of used products can further be promoted and supported. Furthermore, regulatory policies are highly influential on business models and incentivizing policies related to taxations and subsidies are mentioned frequently as supporting strategies for circular business models, products and supply chains. However, studying the existing policy and legislative measures in terms of their influences in facilitating or impeding the CE transition is almost non-existing in literature. In this respect, this research fills in an important research gap by identifying the obstacles that hinder the implementation of CE in the white goods and automotive sector and determining the needs for new policies and potential adjustments of existing legislations.

4. Methodology

4.1. Research approach

Based on the aim and the context of the study, which focuses on two illustrative cases, retrieving information from multiple sources and comparing various types of information from different sources is required in order to perform an analysis and make conclusions. Therefore, an abductive research approach is considered to be suitable where theory and data are combined in an iterative manner (Dubois & Gadde, 2002). Theoretical concepts and insights from previous research are obtained through literature review and the empirical data is based on interviews, reviewing EU legislations (directives) as well as relevant reports and white papers. Figure 2 illustrates the steps and activities involved in the methodology of this study.

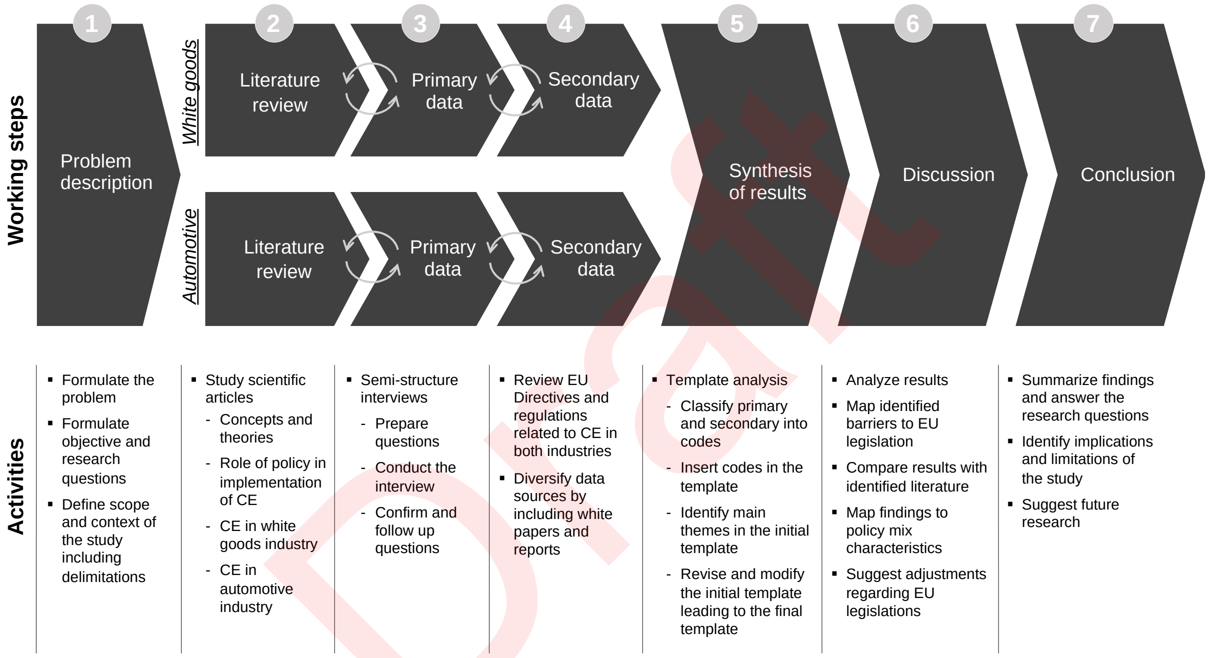

Figure 2. Methodological steps of the study

4.2. Data collection

The main and primary sources of the data collected during this study are the conducted interviews. The interviewees are mainly employees at the companies operating in both industries who are knowledgeable and experienced in CE in their respective positions. The secondary sources of the collected data are EU directives and non-academic white papers in the form of reports and publications relevant to the implementation of CE in the two industries of interest in this study. These documents are conducted by other firms, associations or the European Commission.

4.2.1. Interviews

Based on the research questions of the study, qualitative data are collected through semi-structured interviews. The interviews are conducted with the business contacts representing the white goods and automotive industries in the consortium of the ReCiPSS research project. The data collected during the interviews mainly originate from different actors in the value chains with various business models and challenges, which in some cases have resulted in a different point of views. In the case of companies representing the white goods industry, one actor is an Original Equipment Manufacturer (OEM) producing washing machines, which plans to implement CBM by providing washing machines as services to customers based on a pay-per-use model. The second actor is a service providing SME, which offers purchased white goods appliances to customers based on a pay-per-use model. In the case of companies representing the automotive industry, the OEM producing automotive spare parts plans to implement circular supply chains. The OEM together with a service provider will establish the reverse logistics infrastructure for used automotive parts in order to close the resource loops. In addition, the interviews have also been conducted with researchers in academia and managers in consulting firms in order to include more diversified perspectives and opinions in the data collection process. Table 1 shows the details of the interviews.

Table 1. Details of the interviews

Interview	Position/Title	Company/Institution	Field of expertise
IN1	Head of R&D	White goods OEM	Project management, business strategy, research
IN2	Project manager	Automotive service provider (reverse logistics)	Project management, circular economy, remanufacturing
IN3	Project manager	White goods OEM	Project management
IN4	CEO	White goods service provider (pay-per-use)	Management, strategy, operations
IN5	Business manager	Automotive OEM	Remanufacturing, management
IN6	Manager	Automotive OEM	Circular economy, supply chain, logistics
IN7	Strategy manager	Consultancy firm	Circular economy, project management, remanufacturing
IN8	Management consultant	Consultancy firm	Circular economy, research, manufacturing
IN9	Professor	Academic institution	Circular economy, project management, manufacturing, research
IN10	Researcher	Academic institution	Circular economy, research

All semi-structured interviews have been conducted through voice/video calls due to practical reasons since participants are mostly located in various countries. The duration of each interview has been approximately 30-60 min. In conducting each interview, the set of questions have been adapted to the experience and knowledge area of the interviewee in order to ensure the relevance of responses. The questions relevant to the topic of the study have been prepared using the information retrieved from literature, EU legislations and relevant reports.

During some interviews, other key employees with relevant experience have also been identified by the respondents who have later been contacted for gathering further information. After each interview, a summary of the interviewee's responses has been prepared and sent to the respondents. The purpose of the summaries has been to ensure that all mentioned points are compiled in a structured way and to confirm the discussed points with the respondents and ask follow-up questions. This has been helpful in maximizing the collection of qualitative data.

4.2.2. Research Review

4.2.2.1 Directives

Based on the topic of the study and the research questions, it is necessary to review the legislations that are in force within the EU, which directly and indirectly can affect the transitions to CE. Therefore, EU legislations in the form of directives and regulations have been investigated in order to identify what is required from companies operating in the two industries in terms of laws and if the requirements can in some cases create barriers. In addition, reviewing the relevant directives has been helpful in formulating some of the questions for the interviews and understanding the respondents' views and experience regarding the legislations. During some interviews, the respondents have referred to a specific legislative barrier, which resulted in investigating a specific directive in more detail. Table 2 below shows the directives that have been studied for during research review.

Table 2. Details of the reviewed directives

Directive number	Directive name	Legislation category
2009/125/EC	Ecodesign	Environmental impact, energy saving
2012/19/EU	Waste electrical and electronic equipment (WEEE)	Pollution control measures, waste recycling, environmental risk prevention, electronic waste
2008/98/EC	Waste	Prevention of pollution, environmental protection, waste recycling, public health
2006/123/EC	Services in the internal market	Freedom to provide services, administrative cooperation, right of establishment, services contract
2000/53/EC	End-of life vehicles (ELV)	Environmental protection, waste recycling, waste, vehicle, waste disposal
2011/65/EU	Restriction of the use of certain Hazardous substances EEE (RoHS)	Marketing standard, waste recycling, hazardous waste, electronic waste

4.2.2.2 *White papers and reports*

In order to add more insights to the subject of the study and to diversify the data sources, non-academic white papers have also been used as secondary sources in this study. The white papers include reports and newsletters conducted by other associations and firms operating in the same industries. These documents have been helpful in including more perspectives, which have increased the validity of conclusions made in this study. In addition, white papers have been useful in collecting the data that in some cases was not possible to retrieve through interviews. Table 3 shows the selected white papers that have been used as secondary data in this study.

Table 3. Details of the selected white papers and reports

Author	Year	Title	Content
European Commission	2020	*Circular Economy Action Plan For a cleaner and more competitive Europe*	The new action plan providing an agenda for accelerating transition towards CE.
APRA Europe	2019	*APRA Europe News*	Newsletters published by APRA Europe, containing discussions with experts on legal aspects in remanufacturing.
ERN	2017	*Targeted Recommendations for Horizon 2020*	A report containing identified barriers to remanufacturing and recommendations to key actors.
International Resource Panel (IRP)	2017	*Workshop report on promoting remanufacturing, refurbishment, repair, and direct reuse*	Workshop documentation containing discussions of measures by international experts regarding market and policy barriers to promote circular economy processes.
REMATEC	2016	*Policy primer impacting remanufacturing within automotive industry*	A blog by an expert discussing the impact of EU policies on automotive remanufacturing.

All steps i.e. literature review, data collected from interviews as well as secondary data (EU legislations and white papers), have been used in an iterative way which has resulted in a more effective data collection. For instance, the information from an EU directive has resulted in a question for the interview, which in turn needed to be investigated in the literature. Similarly, few EU directives creating legal barriers for the industries have been referred to during the interviews.

4.3. Data analysis

The empirical findings are analysed using Template Analysis method which is a type of Thematic analysis used for analysing qualitative data (Saunders et al., 2016). In Template Analysis a share of data is coded which results in an initial template (King & Brooks, 2016). The initial template is a hierarchical list that contains codes and themes (Saunders et al., 2016). The initial template is then modified and reapplied iteratively as more data sets are analysed resulting in a final template. The advantage of Template Analysis is that it is a flexible method for analysing qualitative data and it can be adjusted based on the context and the settings of the study. In addition, the initial Template is useful to create a systematic structure for the collected data already in the early stages of data collection (King & Brooks, 2016). The template is revised until all collected data is coded and key themes are identified (Saunders et al., 2016). The template is modified based on the following principles:

1. Insertion of a new code when there is no code existing in the template for the newly identified issues through data collection
2. Removing unnecessary codes from the template
3. Merging distinctive codes when necessary
4. Modifying the template and so that some codes/themes are moved to higher or lower levels
5. Changing the scope of a code and move the codes within the template which may result in splitting the code into more codes

The data collected through semi-structured interviews have then been classified into major categories of themes in order to identify the main barriers for the implementation of CE in white goods and automotive industries. The identified barriers have been mapped to EU legislations and compared to the results from previous research studies. Finally, the findings have been evaluated and discussed using the policy mix characteristics in order to address potential adjustments in the legislative context, to facilitate the adoption of CE practices in the two industries.

In this report in order to ensure methodological rigor, several actions have been taken. First, in order to construct validity, the findings from primary sources have been compared with secondary sources with the aim of including multiple data types and identification of potential coherence or contradictions. Second, in order to construct external validity, it has been attempted to interview different actors in the same value chains in order to include various points of views. Also, in addition to companies representing the two industries, external experts from academia and consultancy firms have been interviewed in order to confirm the findings. Third, to ensure the reliability of the study, summaries of responses have been communicated with interviewees after each interview to minimize false interpretations and misunderstandings.

5. Results

5.1. Key EU directives for white goods and automotive industry

During recent years, various initiatives have been taken by the EU with the aim of making consumption of natural resources more sustainable and decrease waste generation (Milios, 2018). The most recent initiative is the new Circular Economy Action Plan (European Commission, 2020a), which mainly relates to sustainable products, reduction of waste and empowering consumers and public buyers. The new measures addressed in the recent CE Action Plan indicate that the current legislations will be revised in order to scale up circularity of products and services. This means that the current EU directives in force will be adjusted and new regulations will be introduced. The new measures also include the two industries of interest in this study, which implies that the legislative adjustments will affect the operations of companies active in these industries. The current existing directives that are relevant for the white goods and automotive companies are summarized in Table 4. In the following sections, these directives are categorized, and the main relevant requirements are briefly described.

Table 4. Summary of EU legislations relevant to white goods and automotive industry

Relevant industry	Directive	Requirements/principles stated by the directive
White goods industry	Directive 2012/19/EU on WEEE	• 'Producer responsibility' principle • Minimum collection rate (65% of EEE on the market or alternatively 85% of generated WEEE) • Restrictions for shipment of WEEE • Minimum reuse and recycling targets (80%) for home appliances • Minimum recovery targets (85%) for home appliances
White goods and automotive industry	Directive 2008/98/EC on waste	"Waste hierarchy": (1) Prevention of waste (2) Preparing for reuse (3) Recycling (4) Recovery (5) Disposal
White goods industry	Directive 2009/125/EC ecodesign requirements for energy-related products	• Ecodesign requirements • Providing spare parts for a minimum period of 10 years • Access to information regarding repair and maintenance
White goods industry	Directive 2006/123/EC on services in the internal market	• Trade in services among EU member states • Point of Single Contact (PSC) • Simplified administrative procedures • Access of consumers to services within the EU
Automotive industry	Directive 2000/53/EC on end-of life vehicles (ELV)	• Minimum reuse and recycling rates (85%) of EoL vehicles and equipment • Minimum reuse and recovery rates (95%) of EoL vehicles and equipment • Restriction on use of hazardous substances

		• Financial responsibility of manufacturers in the collection of EoL vehicles and equipment
White goods and automotive industry	Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS).	• Restrictions on the use of hazardous substances • Increase reuse and recycling of EEE products • Compliance of imported EEE with the directive

5.1.1. Waste management

Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE) has been established with the purpose to improve the necessary treatments of EoL products (European Commission, 2020d). According to this directive, producers of EEE are allowed to individually or collectively set up systems for the collection of their used products. The Extended Producer Responsibility (EPR) is also defined within the context of this directive, which financially obliges the producers of EEE products to be responsible for the collection of generated WEEE and necessary EoL treatments. It is also required that annual minimum collection rates are achieved. The minimum collection rates since 2019 are 65% of the average weight of EEE placed on the market during the last three years or alternatively 85% of generated WEEE (European Commission, 2012). In addition, 80 % of WEEE related to home appliances shall be prepared for reuse and recycle. The directive also puts restrictions on the shipment of waste for which specific regulations must be followed.

Directive 2008/98/EC on waste is related to definitions and treatments of waste management. Waste hierarchy concept is introduced in this directive, which obliges member states to follow a set of prioritizations when it comes to waste management. As shown in Figure 3, the first priority is the prevention of waste. For generated waste, the options in order of preference are reuse, followed by recycling, recovering and disposal (European Commission, 2019b). This directive is amended by directive (EU) 2018/851 which states that the targets for reuse and recycling should increase in order to improve resource efficiency and implementation of CE (European Commission, 2018).

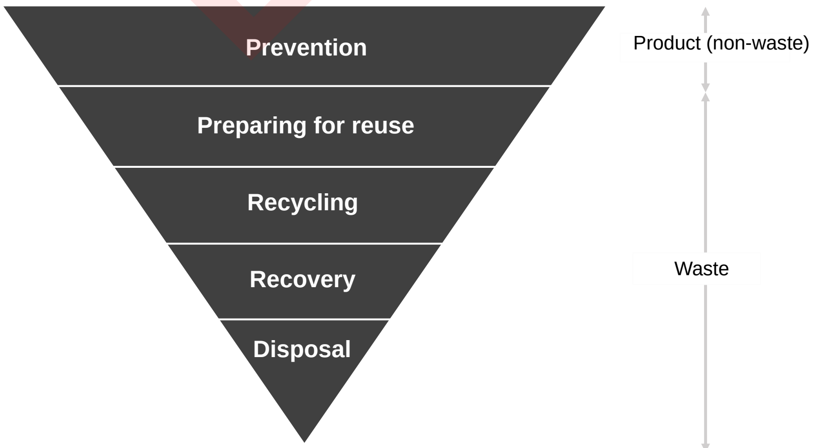

Figure 3. Waste hierarchy introduced in directive 2008/98/EC, adapted from (European Commission, 2019b)

Directive 2000/53/EC on end-of-life vehicles (ELV) is established with the aim to reduce the generation of waste related to vehicles and automotive equipment. Minimum target rates for reuse and recycling as well as reuse and recovering of vehicles and automotive equipment have been set to 85% and 95% of average weight respectively. The use of hazardous substances such as lead, mercury and cadmium in automotive parts has been restricted. Also, recovery of material and components of EoL vehicle should be in compliance with guidelines and hazardous material should be removed. In addition, vehicle and equipment manufacturers, in the production phase, should consider disassembly, reuse, recovery and recycling of the material and components at EoL of vehicles. Collection of EoL parts and authorized treatment facilities should also be provided where the costs of collection and treatment of EoL vehicles are covered by the producers. In treatment processes, suitability of components for reuse, recovery and recycling should be preserved. Reuse of components should not harm the environment by emissions and hazardous substances. Similarly, standards and guidelines should be followed in the recovery and reuse of components. Moreover, information regarding disassembly of components, reuse, recovery, hazardous substances and testing should be provided by the producer within 6 months after a new vehicle has been put on the market (European Commission, 2000).

The directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) has been established with the aim of protecting human health and the environment as well as the promotion of recycling and reuse of EEE products. According to this legislation, use of hazardous substances such as lead, mercury, cadmium in EEE products has been restricted and should be replaced by safer and more environmentally friendly substances (European Commission, 2020c). In addition, importers should ensure that the imported EEE products comply with the directive and that the manufacturers have followed appropriate assessment procedures regarding for instance technical documentations and labels (European Commission, 2011).

5.1.2. Repairability requirements

Directive 2009/125/EC establishes minimum requirements so called eco-design requirements on energy consuming products to be sold and used in the EU (European Commission, 2009). In 2019, a set of regulations related to the directive have been put in place, which defines these requirements for 10 specific product categories. The regulation relevant to this study is the Commission Regulation (EU) 2019/2023, which sets specific eco-design requirements for household washing machines and household washer-dryers with the aim of facilitating easier repairs of appliances. For instance, from March 2021, manufacturers are obliged to provide a certain spare part for washing machines for a minimum period of 10 years after the last unit has been put on the market (European Commission, 2019a). In addition, the spare parts should be provided within a shorter amount of time (15 working days) and the access to information regarding repairs and maintenance shall also be provided to professional repairers.

5.1.3. Providing Services within EU

Directive 2006/123/EC on services in the internal market has been put in force in order to facilitate trade in services within the EU by simplifying the administrative procedures and increasing the cooperation among EU member states. According to the directive, businesses established in the EU are allowed to provide services in other member states (European Commission, 2006). For this purpose, member states should provide Points of Single Contact (PSC), which allows service providers to receive the information they need regarding e.g. country's specific laws and requirements and complete necessary administrative procedures online. According to the directive, the member states should eliminate discriminatory and restrictive requirements related to for instance nationality or residence. The access of consumers to services provided in other EU countries should also be facilitated.

The future revision and adjustments of the directives that concern the automotive and white goods industries are briefly explained in the most recent CE Action Plan. Regarding white goods products which belong to the EEE and energy consuming product category, repairability and durability of products are highly prioritized. In addition, the legislations will be revised in order to improve the collection and treatment of WEEE. Moreover, the coherence of regulations regarding restrictions of hazardous substances in EEE products with other relevant legislations such as the Ecodesign directive will be considered. Regarding automotive parts, the ELV directive will be revised in order to improve EoL treatments particularly recycling. It is also mentioned that the use of recycled material in certain components will be considered in order to increase the recycling rate (European Commission, 2020a).

5.2. Legislative barriers and adjustments identified for white goods industry

Adoption of CE through service-based business models in white goods is an emerging phenomenon and still at early stages. Different actors in the value chain with various business models face different challenges in transitioning from product sales to service offers. The results in this section mainly originate from two different actors. One actor is a manufacturer producing white goods products, which plans to implement circular business models by providing white goods appliances as services to customers based on a pay-per-use model. The second actor is a service provider SME offering purchased white goods appliances to consumers based on a pay-per-use model. In the following sections, the main identified challenges for these two actors in terms of legislative barriers in the adoption of CE within the context of EU regulations are presented.

5.2.1. Servitization challenges

5.2.1.1 Issues related to cross-border service offers

EU policies support companies in providing services in other EU member states. Companies adopting circular business models in different EU member states with different national regulations can result in practical complications. For example, in Austria in terms of regulations related to employment contracts or translation of documents into local languages (IN1). Such complications can be related to legal issues regarding labour regulations or service contracts.

> *"Service providers are allowed on legal basis to offer services in different EU member states other than the state in which they are established. In practice, however, differences in national regulations can create obstacles and should be more harmonized".*

5.2.1.2 Uncertainty in classification of pay-per-use business model

Circular business models based on pay-per-use services for home appliances are relatively at a niche level in the EU. Therefore, definitions and concepts related to such business models need to be improved in order to facilitate their communication and create space for operating circular businesses. Although there are laws for service-based and product-based business models, in some cases, for example, it is not clear which business category their business model belongs to and which laws related to which business model should be applied exactly (IN4).

> *"Classification and definitions related to pay-per-use business models in terms of regulations and laws need to be improved for upscaling the business model and better communication to consumers."*

5.2.1.3 Uncertainty in evaluation of service-based business model

In the adoption of circular business models, service-based SMEs (that do not manufacture washing machines themselves but purchase them from the market) may face more challenges as these models are often perceived as rather risky due to the short-term focus of financial institutions when evaluating projects and granting loans (IN8). It has been clarified that in providing pay-per-use services for washing machines to customers, the purchase of appliances needs to be financed through loans from financial institutions e.g. banks. However, it may be difficult to convince banks of financial stability of the business, particularly at the early stages due to high debt and low revenue (IN4). In addition, in pay-per-use models, the ownership of the appliances remains with the service provider. Still, the collection of the assets (washing machines) is not legally permitted in case consumers are financially not committed and stop their payments. It has been further explained during the interview with the service providing company that this lack of clarity regarding the ownership of appliances creates uncertainty for financial sponsors, in their evaluations when issuing loans for service-based start-ups. Many banks are not willing to financially support these ideas because they may not be able to retrieve their assets in case the business is not successful (IN4). Therefore, in emerging circular service-based business models and the changing nature of cash flow as well as ownership, new assessment methods for financial institutions are required (IN8).

> *"One challenge for service-providing SMEs at early stages of the business is that circular business models are often evaluated as risky by financial sponsors."*

5.2.1.4 Lack of appropriate tax incentives

Regarding taxations, it has been pointed out in the interview with the service providing company that currently, service-based companies providing pay-per-use for home appliances are classified in the same taxation category as product-based manufacturers operating in linear setups (IN4). Reducing taxes for companies providing pay-per-use services has been referred to as an effective factor, which can support these business models and encourage established manufacturers to take these opportunities (IN4). Similar opinions regarding tax incentives have also been expressed by the manufacturing company highlighting that CE will work if there will be a business case behind it for the companies (IN3).

> *"Creating financial incentives such as reducing taxation on service-based business models can encourage both small and established players in the market to adopt circular business models."*

5.2.2. Reverse flow and End-of-Life challenges

5.2.2.1 Immature infrastructure for collection of used appliances

As mentioned in section 5.1.1, according to the EPR principle the producers are financially responsible for collection and treatments of EoL products. In practice, however, producers collectively comply with this obligation, i.e., a Producer Responsibility Organization (PRO) performs the EPR on behalf of producers (European Commission, 2014). In the case of the white goods manufacturer, it has been clarified in one of the interviews that the costs of collecting used appliances are paid based on their market share in each country through collaborating with a PRO for collecting and recycling the used washing machines (IN1). Regarding the collection rates, it has been further explained in another interview that the company is an active stakeholder of Producer Responsibility Organization (PRO) in many EU countries. PROs are collecting and treating EoL appliances and need to achieve collection target rate. Regarding collection rates, it has been pointed out that only a few member states and their PROs have reached the target due to different reasons e.g. inadequate separation of WEEE within households, illegal collection, inappropriate treatment of

WEEE, etc. (IN3). It is often more cost-efficient for manufacturers to collaborate with a third-party for collection of EoL appliances collectively instead of individually take charge for collection and necessary treatments of the EoL appliances separately in each EU member state they operate. It has been further clarified that in practice, a third-party actor in the value chain benefits from the recycled material. In this context, it has been argued that creating economic incentives for manufacturers can make such processes profitable and therefore be effective for individual involvement of manufacturers in collection and necessary EoL treatments of used products (IN1).

> *"The Extended Producer responsibility (EPR) is mainly implemented collectively where a third-party e.g. Producer Responsibility Organization (PRO) is in charge of collecting and recycling the EoL appliances. EPR is a cost for the manufacturers where the PROs benefit from the recycled material."*

Furthermore, the collected EoL appliances may be appropriate for different EoL strategies i.e. reuse, repair or refurbishments, depending on their status and level of functionality, which preferably is to be assessed by the manufacturer. Involving a third party for collection of used products means that the manufacturer and the customers are not in direct communication and collaboration. Regarding enhancing the communication to customers, it has been explained that PROs are running many awareness-raising projects to increase collection of WEEE, while the collection for reuse, repair or refurbishment is at early stages. Responsibilities regarding the safety and functionality of the appliances after reuse or refurbishment need to be defined through for instance amendments to legislation, standards or guidance for households (IN3).

> *"Collection of EoL appliances through EPR are mainly for material recovery through recycling. Collection for the repair, reuse and refurbishment purpose is still at early stages. Standards and guidelines are required to clarify the safety and functionality criteria."*

In the case of service providing company, the appliances are collected from consumers directly for necessary repairs. It has been highlighted during the interview with the service providing company that the reverse stream and collection of used appliances is challenging when other third-party actors in the market are involved in taking back the used appliances, repair and deliver them back to the consumer. The appliances may arrive in wrong places or become damaged when independent logistic companies are involved since these actors are mainly familiar with handling EoL appliances that no longer can be used (IN4).

5.2.2.2 Prioritization of recycling over reuse in End-of-Life strategies

It has been pointed out by one of the respondents that the current waste-related directives stimulate mainly recycling rather than reuse practices (IN8). Whereas according to the European waste hierarchy (see Figure 3), waste prevention and reuse are prioritized over recycling. One view on potential adjustments in legislations in this context has been related to the EPR highlighting that legislation should recognize reuse within EPR and consider these activities within the collection targets (IN3). The WEEE directive also requires certain target rates for reuse and recycling (80%) as well as recovering (85%) of used appliances (European Commission, 2012). Regarding the mentioned target rates and potential improvements, it has been pointed out that used appliances are often recycled and not reused. This target rate is a shared target that covers both recycling and reuse; a separate target for reuse should be set in order to promote reuse (IN3).

Similarly, the waste directive also involves regulations aiming at improving waste management and promote EoL strategies such as recovering, recycling, remanufacturing, and reuse. It is stated in the directive that certain criteria regarding quality, treatment techniques, product standards, etc. should be followed for recovering and recycling material (European Commission, 2018). Regarding improvements in such regulations for more effective treatments of used appliances, it has been pointed out by the manufacturing company that as soon as the used appliance is delivered by the owner to the waste collection point, it is considered as waste. In this case, further processes must consequently comply with environmental legislations. It has been further explained that in practice, the process of returning the appliance to the market is neither rational nor transparent in terms of responsibility (IN3).

> *"The current legislation related to waste management mainly stimulates recycling. More detailed legislations are required in order to make reuse of EoL appliances possible in practice by clearly defined responsibilities and guidelines."*

As it has been mentioned earlier, the white goods manufacturer is preparing to adopt a circular business model and provide pay-per-use services for the washing machines. In that case, the ownership of the appliances remains with the manufacturer and it has been pointed out that it would be preferable to collect and transport the used appliances back to the manufacturing country for necessary repairs, refurbishments or remanufacturing. This will aggregate the collected used products in one location, which prevents generating waste in multiple EU member states (IN1).

In the case of service providing company, the components of EoL appliances that can be used are saved, and the remaining components are sent to recycling companies. As it has been explained by one of the interviewees, the recovery of used appliances can be improved if the manufacturers would take back certain parts. However, they may not be willing to do so since refurbishing the used appliances may not be cost-efficient (IN4).

> *"Some EoL parts that are recycled can still function if they are refurbished."*

5.2.2.3 Repairs and spare part supply requirements

According to the directive 2009/125/EC, energy consuming appliances are obliged to comply with certain eco-design requirements before they are put to the market in the EU (European Commission, 2009). One of the specific requirements for washing machines and dryers (regulation 2019/2023) is that the manufacturers should provide spare parts for their products for at least 10 years after placing the last unit on the market (European Commission, 2019a). Referring to the impact of this recent regulation on the white goods company it has been pointed out that the white goods manufacturer is already aiming at providing 10 years of spare parts support and repair, therefore the challenges already exist (IN3). The challenges have been explained to be mainly related to higher inventory costs for storing the spare parts in stock for longer periods of time (IN1). It has also been pointed out that when transitioning to service-based business models and providing pay-per-use services, the manufacturer will need to take back and repair the appliances using the spare parts and used components that still function (IN1).

In the case of service providing SME, it has been explained that the appliances are repaired mainly by the company as far as possible. However, in some cases, it is required to refer to the manufacturers for receiving spare parts (IN4). Regulations such as eco-design obliging the manufacturers to provide spare parts for a longer time to customers (European Commission, 2019a) is perceived positively by the service providing company since the repairability of appliances are increased through such legislations. However, it has been further pointed out that other complementary measures are also required to ensure that the spare parts are provided at fair prices. This becomes a concern particularly when the warranty on the appliances is no longer valid, as a result, manufacturers do not accept to repair the appliances free of charge (IN4).

"Legislations making spare parts mandatory are effective in increasing the repairability of appliances. However, producing more spare parts can increase inventory costs for manufacturers which in turn may result in higher pricing of spare parts."

As it has been argued during the interview with the service providing company, manufacturers have a great opportunity to establish pay-per-use business models since they produce spare parts themselves and are able to reuse them. They are therefore not dependent on another actor, which makes the repairs considerably simpler (IN4). In the contrary, the service providing SMEs offering appliances based on a pay-per-use model, are dependent on manufacturers for major reparations or receiving spare parts which can often be challenging.

5.2.2.4 Limitations in cross-border logistics

In the adoption of circular business models, the return of the used products to the manufacturer is required for necessary repairs, refurbishments, remanufacturing or direct reuse. In some cases, the return of used appliances involves cross-border transportations when the manufacturing plant is located in another EU member state. In this context, it has been explained that when the used appliances or components are considered as waste, then environmental permits are required (notifications for cross-border shipment also within the EU) (IN3). It has been clarified by another respondent that these restrictions can in practice cause difficulties in the process of returning EoL appliances or components from the market to the manufacturers for necessary repairs or preparations for reuse and then transport them back to the customers (IN1). These obstacles can in some cases result in discarding the used appliances or components rather than repairing them; since it is more cost-efficient to replace them with newly manufactured washing machines instead of transporting and repairing the used appliances or components (IN1). It has therefore been suggested by one of the interviewees from the white goods manufacturing company that re-evaluating and improving definitions related to the categorization of waste could be an appropriate solution to this issue in order to distinguish waste from used appliances that require reparations (IN1).

"Classification of EoL products as waste can in practice, due to difficulties and administrative procedures, result in discarding used appliances and components which are repairable and can be reused."

5.3. Legislative barriers and adjustments identified for automotive industry

In the context of CE and reducing resource consumption, automotive remanufacturing is a good example that has been well-established and practiced for decades in the EU (APRA Europe, 2019a). The shorter loop in remanufacturing as an EoL strategy shows the benefits of remanufacturing i.e. more added value in form of remaining material and energy is conserved through remanufacturing compared to recycling. Remanufacturing can be beneficial for the automotive companies in reducing the costs and effort in terms of resources required for manufacturing new parts. However, as it has been pointed out by one of the interviewees, remanufacturing, despite its benefits, for most companies is considered mainly as a side-business in the aftermarket. Only a few companies have developed strong and thriving remanufacturing operations (e.g. Caterpillar). It has been further explained that as remanufacturing is not treated as a large-scale activity, it has remained on a niche level. Most automotive companies prefer to manufacture new products. This mind-set is partly due to low demand in the market and partly due to manufacturers' concerns regarding cannibalization of their new product sales as a result of remanufacturing used products (IN7).

"The automotive companies mainly prefer new sales to remanufactured sales, even though the remanufactured ones are often more profitable. In addition, there is not

enough pull from the market for remanufactured products and there is lack of engagement in developing this market."

The reason behind why major automotive companies have adopted such mind-sets and do not perceive remanufacturing as an attractive and main business model can be investigated from a policy point of view. In the following sections, major obstacles and potential adjustments identified for remanufacturing related to institutional and legislative factors are presented and discussed.

5.3.1. Lack of clear End-of-Life definition for used parts

In automotive remanufacturing, the used parts which are called "cores" are necessary in order to implement the set of processes that are needed to remanufacture (ARPA Europe, 2016). Several respondents have pointed out that the cores are considered high-value products as they have the potential to be remanufactured and reused (IN2; IN6; IN8). For this reason, they are actually considered as valuable resources that are traded i.e. they are acquired through "economic exchange" and therefore are not collected and treated as discarded waste. It has been further clarified that in some cases, particularly when cores are collected from scrapyards, they are legally considered as waste which has been referred to as one of the main issues regarding remanufacturing in the automotive industry (IN2). This issue was highlighted as one of the main barriers during one of the interviews with the company that manages reverse logistics processes related to remanufacturing of automotive parts.

> *"The problem in automotive industry and in a B2B context is that the products we handle are actually not waste and that the cores can be considered as used or damaged products and not waste. Cores should actually be considered as resources since they can be reused."*

The importance of legal definition of cores and distinguishing them from waste has also been emphasized in a workshop report by International Resource Panel (IRP). It has been highlighted that the remanufacturers perceive cores as economically valuable and as a result put the effort in appropriate packaging, labelling and transporting them. Therefore, they are not categorized or treated as waste from remanufacturers' point of view (International Resource Panel, 2017).

In addition, it has also been explained by one of the interviewees that specific waste-related laws and regulations are applied when the status of cores is legally recognized as waste. Although waste-related regulations are effective in reducing waste generation, in this context, however, they may hinder extracting the value of cores for remanufacturing in practice (IN2).

> *"Defining cores which have high potential for remanufacturing as waste can prevent an efficient circular economy as it can indirectly result in recycling materials of the product rather than preserving their value for remanufacturing."*

It has been acknowledged that it is difficult to expect lower restriction related to waste management, since it may jeopardize necessary treatments for the actual waste. Therefore, specified definitions, more careful and detailed assessment of cores and their status have been suggested to ensure that their value and potential is preserved through remanufacturing. This has been referred to as an important step in the adoption of CE in an efficient way in the automotive industry (IN2).

Moreover, it has been explained by another respondent that remanufacturing involves many different processes, which are not fully automated and therefore requires manual work (resulting in high costs for companies (IN7). In addition, legal classification of cores into waste means that many of these processes are also classified as processing waste which increases the costs even more for the remanufacturers due to for instance administration costs (ERN, 2017).

5.3.2. Challenges in trade and cross-border logistics

Access to used parts or cores plays an important role in remanufacturing automotive used products. Therefore, setting up an efficient system that ensures the return flow of cores is crucial for companies adopting remanufacturing business models (APRA Europe and ReMaTec, 2019). The imbalance of core supplies in different countries can create the necessity and opportunity to transport the cores between different countries for remanufacturing purposes. However, categorization of cores as waste can make their cross-border transportations and trades complicated since there are high restrictions on import and export of waste into and out of countries. This can influence the efficiency of reverse logistics processes involved in remanufacturing (ERN, 2017). In addition, most automotive companies operate globally which means many international trades and cross-border transportations are common. Regarding remanufacturing, cross-border transportation of the cores can in some cases create obstacles in establishing efficient reverse logistics. Therefore, identifying the trade barriers influencing the flow of cores between countries plays an important role in ensuring an efficient core supply. As it has been highlighted by World Trade Organization in a workshop, trade tariffs do not create obstacles for trading the cores since new and remanufactured products are in the same tariff rate categories. However, the absence of a consistent definition for the cores and classifying them as waste can create obstacles in the trade since more restricted rules are then applied to these parts. It has therefore been suggested to introduce a distinct trade classification for remanufactured parts and cores in which consistent international standards are applied. This can ensure that coordinated measures are implemented in specific processes such as assessments, inspections and cross-border transportation of cores and remanufactured parts (International Resource Panel, 2017).

Similar aspects have also been addressed by one of the interviewees. It has been pointed out that there are minor issues related to custom clearance in countries such as Switzerland and Norway since these countries are not members in the European Union and the Custom Union; therefore, specific documents are required to move the used product across the border (IN2). It has been further explained that issues related to trade and cross-border transportation can become more challenging on an international level due to different national regulations in different countries. It has been clarified by the respondents that the cross-border issues related to import and export of cores and remanufactured parts are mainly related to countries outside of the EU (IN2; IN6). For instance, remanufactured parts can be sold to Turkey if they have been manufactured in the country. In Russia, references to the vehicle that the used parts come from are required, and in Northern America, specifications regarding the parts' country of origin need to be included (IN2).

> *"These factors can make trading and cross-border transportation of remanufactured parts or cores from and to these countries complicated in practice. Remanufacturing industry is currently at niche level and the regulations regarding remanufacturing of used parts can be more harmonized."*

Within the EU however, it has been pointed out by the interviewees that there are not any major challenges hindering the cross-border transportation of cores and remanufactured products (IN2; IN6). In contrary, in a workshop report by IRP, it has been pointed out by a remanufacturing company that the legal definitions of used automotive parts and their association to waste can create obstacles related to cross-border transportation of cores and remanufactured parts (International Resource Panel, 2017). It has been explained that the term "waste" is used as a very generic definition in the context of waste management in the EU legislations such as directive 2008/98/EC, which addresses EoL products or any discarded object as waste. The conditions of the EoL products are not specified based on their value, potential and status. Furthermore, these definitions may vary in different EU member states which can result in barriers related to trading and cross-border transportation of the used products (International Resource Panel, 2017). Transportation of waste is highly restricted in the EU, which may result in difficulties and high costs for companies. These factors may discourage companies to engage in EoL activities including remanufacturing of the used parts. A regulation in the EU that distinguishes the cores from waste resulting in correct separations has been suggested as a solution.

5.3.3. Remanufacturing challenges on product level

5.3.3.1 Quality certifications and standards

Quality certifications and standards can demonstrate a certain level of quality for the customers in order to ensure that the remanufactured products have been through specific processes and therefore comply with original product specification (ERN, 2017). Regarding the impact of quality certifications on customers' choice, multiple interviewees explained that the remanufactured parts must have the same warranty as newly manufactured parts. Therefore, for the customer, there seem to be no differences when it comes to the warranty of the remanufactured parts (IN2; IN6; IN7). It has been pointed out that pricing is the factor that mainly makes a difference for customers in their decision-making, which is lower in the case of remanufactured products compared to new products (IN2).

Similarly, international standards e.g. ISO standards can create an alignment and coordination when it comes to processes and definitions used in remanufacturing. Regarding the importance of these standards, it has also been explained by the interviewees that international standards would not necessarily make major differences due to the warranty of remanufactured products that are the same as new products. It has been further clarified that the warranty assures the consumers of the quality. International standards in quality assurance can be useful but may not necessarily have high impacts on remanufacturing in general. However, it has also been clarified that standards are advantageous when the used parts are remanufactured by a third party, in order to ensure a certain level of quality (IN7). This has been confirmed by another respondent clarifying that different remanufacturing companies can follow different standards to assure quality, which does not create serious problems. However, product liability can become an issue when products from a company are remanufactured by a third party or in other countries with different standards (IN2).

> *"Quality certifications and standards do not have necessarily major impacts on customers' choices, since new manufactured and remanufactured products have same warranties."*

The legal issue of product liability in the context of remanufacturing in the automotive industry has been addressed by APRA Europe. On a legal basis, remanufacturers are considered manufacturers and therefore, in case of damages, are held responsible and should compensate for property or personal damages on remanufactured products (APRA Europe, 2019b). It has been further explained that it is therefore important for remanufacturers to evaluate the impact of remanufacturing processes on safety of the products. International standards for remanufacturing processes are referred to be supportive to increase transparency and clarity regarding product liabilities in similar ways that standards support transparency and liabilities in the manufacturing of new products.

5.3.3.2 Patents and intellectual property rights

Another subject similar to product liability that can create obstacles for remanufacturers is related to intellectual property such as patents and branding. This issue is particularly relevant for the products that have been remanufactured by an independent actor (a third party) and not the OEM; since to avoid patent infringement the remanufacturer is fully liable to the patent owner i.e. the OEM. Remanufacturing processes such as disassembly and cleaning of cores usually do not have the risk to infringe OEM's patents. However, during reconditioning and reassembly, where the used parts need to be replaced by spare parts, compliance with the patent, is necessary (APRA Europe, 2019a). Therefore, all patents used in the remanufactured product should be traced to ensure that the replacements do not lead to patent claims by the OEM. In addition, the origin of reassembled parts is also important. Using spare parts not provided or permitted by the OEM can result in the patent infringement (APRA Europe, 2019a). It has also been pointed out by an interviewee that infringement of patents is subject that can affect the profitability of remanufacturing business models and create obstacles for remanufacturing activities. Therefore, new collaboration models between remanufacturers and OEMs are needed in order to increase remanufacturing activities that are profitable and at the same time compliant (IN8).

> *"There is a risk of patent infringement when remanufacturing is performed by an actor (independent remanufacturer) rather than the OEM. To minimize the risk, patent information needs to be made available."*

5.3.4. Insufficient measures for promoting remanufacturing

5.3.4.1 Lack of remanufacturing targets

The environmental and economic benefits of remanufacturing due to reduction of resource consumption, and therefore its contribution to CE, have been acknowledged by the EU (ERN, 2017). However, the remanufacturing is not directly addressed within the context of EU policies and legislations specifically aiming at particular measures or actions to ensure that used products with remanufacturing potential are actually remanufactured. The sustainability benefits of remanufacturing outweighing recycling have also been discussed and addressed earlier. As it has also been pointed out by the respondents, current EU legislations, e.g. directive 2000/53/EC on end-of-life vehicles (ELV) mainly stimulate recycling practices, which essentially consist of material recovery and is the most energy-intensive form of recovery (IN8). The target rates are mainly regarding the reuse and recovery of material. 85% of car components should be reused and 95% recovered, which are very prominent regulations for automotive companies (IN7). Remanufacturing is another alternative that recovers components as well as products and not only the materials (IN8). Although component reuse targets can also have positive impacts on remanufacturing, regulations can be improved by addressing remanufacturing of products and setting remanufacturing targets (IN6).

> *"The current EU legislations mainly address recycling by considering target rates for recycling whereas there are not any similar measures for remanufacturing."*

Introducing quotas and target rates for remanufacturing in ELV directive has been mentioned to have an impact in encouraging automotive companies to adopt remanufacturing (ERN, 2017). It has however been pointed out by a respondent that setting remanufacturing targets in practice is difficult because there are no clear definitions for remanufacturing yet compared to reuse and recycling (IN8). Establishing new target rates through regulation can trigger automotive companies to implement the changes that are necessary in order to ensure compliance with certain legislation. It has been clarified by another respondent that automotive companies are very reactive to policy changes. Current policy changes are mostly related to emissions, extended producer responsibility, and recyclability. The first reaction of automotive companies is complying with targets by, for instance, reducing their emissions to reach the required targets. The second reaction is to be prepared and invest in R&D, processes, and business models in order to comply with extended producer responsibility and recyclability. Although automotive companies comply with regulations, they do not seem to be very proactive, but if they are encouraged to adopt CE through regulations, they would follow the trend and regulations (IN7).

Different policies can have different levels of effectiveness. In response to what types of policies are most effective in promoting remanufacturing in the automotive industry, it has been explained that policies that create the most holistic aim are the most effective ones. It has been exemplified that the fleet emissions target at the moment, for instance, is mostly covering the use phase, while a policy covering the entire product's lifecycle would have been more effective i.e. covering production and sourcing, the use phase, and EoL. Such holistic targets are more successful since they offer more flexibility to the OEM to evaluate in which stage they can reduce the emissions in the most cost-efficient way. In this way, they would have the flexibility to make trade-off decisions. Therefore, in terms of CE and policies in this context, it is suggested to aim at a high-level remanufacturing target and allow the automotive companies to make the trade-offs between different strategies (IN7).

> *"Policies that create the most holistic aim, covering the entire* product's lifecycle *rather than the use phase only are the most effective ones as they provide more flexibility in trade-offs and decision-makings for the OEMs".*

5.3.4.2 Lack of appropriate tax incentives

Remanufactured products, despite profitability for the companies due to the remaining value of the cores, can also result in higher costs due to the greater workforce that is required. Remanufacturing involves various manual and labour-intensive processes as well as reverse logistics, which can increase costs for automotive companies. High costs associated with workforce particularly in Europe can make it challenging for companies to compete with imported automotive products at lower prices (ERN, 2017). In this context, it has been suggested by a respondent that creating financial incentives can therefore decrease the overall costs related to remanufacturing. It has been further clarified that the governments need to primarily set the market conditions in the right direction, i.e. how taxation systems are established which requires major changes. Incentivizing policies such as higher taxation on consumption of new resources compared to the reuse of existing resources have been mentioned to be effective in encouraging remanufacturing activities. This would mean higher taxations for the companies that take raw material from natural resources compared to companies that reuse the material that already exists (IN7).

Financial incentives on remanufactured products can be effective in supporting remanufacturing since they can reduce the overall costs and as a result encourage companies to remanufacture used automotive parts (ERN, 2017). One option is to decrease the taxes on remanufactured products. Regarding the workforce required for remanufacturing and the taxation related to the workforce, it has been clarified that the processes in remanufacturing are not fully automated and therefore very labour-intensive. Consequently, paying taxes on labour for remanufacturing particularly in the EU can result in high costs for the automotive companies. Taxation on natural resource consumption would be a better strategy. This could change conditions in the market and the business case quite well (IN7).

On the contrary, it has been pointed out by another interviewee that tax incentives on remanufactured parts can create discrepancies in the market due to price advantages and changes in demand. It has been further clarified that remanufactured and new products should be treated in the same way when it comes to tax classifications which allows remanufactured products to compete on the same level as new products and prove their equal or better performance (IN6).

> *"Tax incentives for remanufacturing and reverse logistics activities can promote remanufacturing. However, there is a risk that such incentives can create a price imbalance between new and remanufactured spare parts."*

5.3.4.3 Limited customers awareness and market availability

It has been pointed out by the respondents that increasing customers' and in general public awareness regarding environmental and economic benefits of remanufactured products is an important strategy to promote remanufacturing (IN6). For doing this, when available and relevant the use of remanufactured products needs to be made mandatory to prioritize over new products (IN5) and the marketing of the environmental benefits of remanufactured parts needs to be improved (IN2). It has also been clarified by another respondent that if customers are informed about environmental benefits of remanufactured parts, as well as their as-new quality, they are likely to choose the remanufactured part over a new part (IN8). It has also been pointed out that in addition to awareness regarding the environmental benefits, it is also important to make remanufactured products available and visible to customers, which in turn can also be effective in the promotion of remanufacturing. It has been exemplified that the access of customers to remanufactured products in workshops should become easier (IN6).

Public procurement has also been mentioned as another strategy, which can create some level of incentive for remanufacturing (IN7). In the EU, 250 000 public authorities spend approximately 14% of GDP each year on purchasing services and supplies (European Commission, 2020b). This shows the potential of public procurement to promote and recognize sustainable business models. Increasing the share of remanufactured products in public procurement can have an impact on the development of remanufacturing industry in the EU. For this purpose, specific purchase targets or quotas in the public procurement can be dedicated to remanufactured products (ERN, 2017).

> *"Increasing public awareness about sustainability benefits of remanufactured products can influence their decision-makings and support remanufacturing. Considering quotas for remanufactured products in public procurement is another effective strategy. It is also important to facilitate the access of customers to availability of remanufactured products."*

6. Discussion and conclusions

The aim of this study has been to address the legislative obstacles that hinder the implementation of CE in two industries, namely white goods and automotive, and how the adoption of CE can be accelerated through possible adjustments in the current EU policy landscape. A qualitative study has been conducted where primary and secondary sources have been used in combination with previous research. The primary data is collected through semi-structured interviews, complemented with secondary sources, such as EU directives and reports, which are then discussed in light of academic literature.

The results show that both industries face different types of challenges in transitions towards CE that can be associated with the current EU policies and require different policy interventions to address the challenges. The following sections provide an analysis of the legislative barriers and suggest possible policy adjustments to facilitate CE transition in the white goods and automotive sector.

6.1. Analysis of legislative barriers and adjustments for white goods industry

The identified themes show that in practice companies, in this case, an established manufacturer and a service providing SME, have different challenges in operating a service-based model. The difference, on the one hand, is that in the case of the manufacturer, which is operating in multiple EU member states, the legislative challenges in transitioning to service offers are often related to cross-border operations. For instance, moving the used appliances or offering services in different EU countries. Whereas in the case of the SME, which offers appliances only as service, the challenges in this category are often related to financing and supporting the circular service-based business model. This shows that different actors deal with different challenges depending on their position in the value chain and the business models they operate. Challenges on financing and supporting may be relevant for most service-based businesses in general and may not necessarily be associated with legislative barriers to CE implementation. However, policies can be effective in reducing such obstacles through more comprehensive legislations considering these differences. This finding is aligned with previous research Kiefer et al. (2019) suggesting that different types of innovations play different roles in sustainable transitions. Therefore, all types of sustainable innovations should be considered with different levels of intensities when creating policies.

The similarity on the other hand is that both actors conceive tax incentives to have potentially high impacts on transitioning to circular business models and service offers. Both actors have pointed out that currently service-based and product-based business models are in the same taxation category which can affect their profitability and in turn possibly the pricing of the offers. This finding is also aligned with previous research indicating that for a successful transition to service-based business models, costs and benefits of both companies and customers should be considered. Consequently, the adoption of the business model needs to be made appealing to both sides (Gnoni et al., 2017)(Loon et al., 2020),(Moreno et al., 2014). Same level of taxation in addition to potentially higher costs related to reverse logistics and repair of the used appliances, may not be economically motivating for manufacturers and service providers. These aspects can affect the willingness of companies in adoption of circular business models and transitions from product sales to service offers.

More specified themes identified, such as offering cross-border services within EU or categorization of pay-per-use business models in regulations, indicate that more comprehensive legislation may be required to address practical aspects related to service offers. So far, issues relevant to service offers are addressed in directives e.g. services on the internal market (European Commission, 2006). However, differences in EU policy and local regulations in EU member states can create practical challenges, which may not be related to policy barriers, but they can discourage businesses to move forward in the circular business space.

The challenges identified related to the reverse flow of used products shed light on legislative barriers for the white goods companies in relation to the collection and treatment of used appliances. The overall results related to this category indicate that the current legislations with the aim of increasing resource efficiency can be further developed in order to facilitate closing and slowing down resource loops in practice. Some of the most important findings in this context are related to the waste related legislations. Legislative frameworks such as waste hierarchy prioritizes a certain ranking of treatments for waste management (see Figure 3). In practice, however, this hierarchy is not implemented in terms of waste management. For example, the waste hierarchy prioritizes waste prevention followed by reuse, recycling, recovery and disposal. The results from interviews show that a major share of used appliances in practice is recycled and not prepared for reuse. This can partly be related to the current legislative system that makes recycling of EoL appliances more convenient and cost-efficient, even though some EoL appliances may be suitable to be refurbished, repaired and reused. As pointed out in the results, there is a lack of specifications and guidelines for reuse and refurbish standards in order to ensure (re)manufacturers that they can safely put the product back on the market. This finding confirms previous research pointing out that there is a need for clear standards and guidelines in order to facilitate reuse of appliances (Kissling et al., 2013; O'Connell et al., 2013). This finding is also aligned with previous research suggesting that reuse of appliances involves more than reverse logistics and transportation. Other issues related to safety, repair and testing need to be tackled as well to ensure the high quality of EoL appliances, which in turn influences the consumers' attitude (Cole et al., 2017).

Moreover, setting common target rates for reuse and recycling, where the two have distinct legal definitions, is in contrary to the prioritization of reuse over recycling. A common target rate can in practice result in prioritizing recycling over reuse since recycling of used appliances is, as mentioned above, often more convenient and more cost-efficient compared to preparing them for reuse. These findings are coherent with previous research suggesting that policies and incentives are required to facilitate and support reuse more than recycling (Dominish et al., 2018; Ranta et al., 2018).

Another important aspect highlighted through interviews is regarding EPR principle with the aim of obliging producers to financially take responsibility for their used products. In practice, many companies pay a fee according to their market share and the actual treatment of used products is thereafter performed by third parties. This also indirectly hinders the implementation of waste hierarchy since defining EPR only in terms of financial responsibility, may not necessarily be sufficient to encourage manufacturers to collect the used appliances, repair and reuse them. As also mentioned by Milios (2018), this setting does not create enough incentives for manufacturers to improve the design of their products for a higher level of circularity. The current system implies that major share of used appliances that can be reused or refurbished may actually not return to the manufacturers.

The findings also point out that the reverse logistics and the current infrastructure of collection of used appliances need to be improved in order to increase the circularity of products and ensure their return to the manufacturers or service providers. In the current infrastructure, collection of used appliances is mainly associated to waste collection and higher costs for companies. Legislation can be effective in this context to transform the current mind-set and make collection of used appliances profitable through incentives. The current setup may not create sufficient incentives for manufacturers to directly be involved when it comes to collection of used appliances and necessary treatments. An important aspect highlighted in the results refers to the status of used appliances and their classification as waste. In adoption of CE and closing the resource loops, used products contain value in terms of resources and hence can be reused, refurbished, remanufactured or recycled. Therefore, in the context of CE, the used products should actually be considered as resources. Considering EoL products as waste can create a mental barrier and therefore limit options for extracting the highest possible product value. As a consequence, environmental regulations are then applied to EoL products on a legal basis, which hinders the return of the used appliances back to the manufacturer for repairs and thereafter to the market for re-sale.

Regarding the lifetime extension of appliances, legislations such as eco-design requirements (European Commission, 2019a) are effective in increasing the repairability of appliances. However, providing spare parts does not necessarily result in more repair of used appliances, particularly if the warranty period is no longer binding. When costs related to repair, spare parts, maintenance and transportations increase, customers (i.e. B2B and B2C) may prefer to purchase newly manufactured appliances instead of extending the use life of the current appliances.

The results in this category have also shed some light on the difficulties that companies may have in transportation of EoL products within the EU. The discarded used products are considered as waste which makes their cross-border transportation complicated as shipment of waste is restricted in the EU and has to comply with specific regulations according to the WEEE directive (European Commission, 2012). On one hand, these restrictions are necessary in order to prevent the accumulation of waste in geographies that have lower environmental standards. On the other hand, these restrictions can also in some cases prevent closing resource loops as it may appear more convenient or cost-efficient for companies not to transport back repairable products. In this context, the question arises why used products are categorized as waste while they can still be refurbished, repaired and reused. This can be an indication that in a CE perspective the current waste definition should be redefined and the status of EoL products in terms of valuable resources should be more carefully assessed, as also suggested in previous research by Hartley et al. (2020)and Bastein et al.(2013).

6.1.1. Implications

Overall, the results show that the adoption of CE in white goods is in its early stages. The industry has been addressed in many EU policies with the aim of increasing the circularity of appliances. Nevertheless, adjustments to the current legislations and policies may accelerate the implementation of CE in the white goods industry. In order to address the issues identified from the discussion above, it can be more effective to use a combination of policies, or a policy mix, as suggested by Bahn-walkowiak & Wilts (2017) and Rogge & Reichardt (2016). Using the policy mix (see Figure 1), the three building blocks are carefully designed and the linkage between them is considered. In this context, the implementation of CE has been addressed in the current EU policy processes and elements. However, considering the issues mentioned above, the characteristics of such policies particularly consistency, coherence and comprehensiveness of CE policies can be improved.

For consistency among policies, it is required that the policy elements are aligned and there are no contradictions between them. The issues discussed above regarding waste hierarchy and prioritization of recycling in practice instead of reuse show that the consistency of such legislations can be improved. Setting separate reuse targets and recycling targets as well as including guidelines for reuse and repair can contribute to the implementation of waste hierarchy in practice and engagement of white goods companies in reuse activities instead of recycling.

For coherence among policies, it is necessary that there is a synergy among policy processes and that they point out the same objective in a parallel manner. While the objective of recent CE policies in EU has been to address the entire lifecycle of products (European Commission, 2020a), the current legislation in the EU is mainly considering the EoL phase and focus on used products as waste (Milios, 2018). More specifically, policies such as EPR mainly address the EoL phase and do not necessarily encourage manufacturers to enhance their product design in terms of circularity. Adjusting EPR policy or creating incentives for producers to benefit from increasing circularity on the entire lifecycle of their products can increase the coherence among such policies.

Comprehensiveness among policies refers to the extensiveness and broadness of the policies and to what degree they consider all markets and drivers for instance. As the finding have also pointed out, the same legislation does not necessarily affect all actors in the industry in the same way due to different drivers and barriers when it comes to sustainability transitions, as also referred to by (Kiefer et al., 2019)). In addition, they may be influenced by the same legislation to different extents due to various level of interdependency among them. Policies capturing these differences in the value chain in transitions from linear to circular systems can play a significant role in creating new opportunities for new actors, hence the development of innovative business models.

6.2. Analysis of legislative barriers and adjustments for automotive industry

The identified categories of legislative barriers and adjustments have highlighted the main areas that may hinder the implementation of CE in the automotive industry through remanufacturing. As the results show, most identified categories, in a legislative context, mainly refer to a lack of adequate specifications and strategies in policies and measures rather than a particular legislation hindering remanufacturing in practice. This can be related to the establishment of automotive remanufacturing in Europe, which has existed for decades. Remanufacturing is, however, at niche level and new policies or adjustment of current policies can help in developing the industry further within EU with the aim of accelerating CE in automotive industry.

One of the main categories identified refers to the absence of clear legal definitions related to remanufacturing and used automotive parts (cores) which have also been mentioned numerous times in previous research (Casper & Sundin, 2018; Guidat et al., 2017; Karvonen et al., 2017). Classification of cores as waste is one example of such definitions. Similar to the findings in the white goods industry, such issues may not necessarily hinder CE on a legal basis. However, they may reduce the engagement of companies to be involved in remanufacturing operations due to lower value perspective and higher costs e.g. administrative costs. Moreover, considering cores as waste implies that waste related regulations are applied which in turn may lower the perceived value of the product even though these products may still function. This may result in prioritizing recycling despite the potential for remanufacturing. While waste-related regulations have primarily been created to protect the environment, the current waste definitions may need to be reconsidered in order to ensure that the status of the cores is assessed more carefully, and their value is maintained at the highest level.

The findings related to trade and cross-border logistics show a difference between the primary sources and secondary sources. The interviewees have conveyed that there are not any major legal barriers hindering the trade and transportation of automotive goods within the EU. Whereas the secondary source shows that the legal classification of cores as waste and thereby high restrictions on shipment of waste within the EU have resulted in obstacles in remanufacturing. The difference in the two statements can be explained based on different business interests and different business models of the actors within similar value chains. Larger companies with extensive global networks are more resourceful in handling bureaucratic obstacles compared to independent actors (i.e. third party) with limited networks, partnerships and global know-how.

The results also show that main issues related to reverse logistics as well as import and export of cores and remanufactured parts are mostly linked to countries outside the EU borders, which is not within the scope of this study. Nevertheless, solving trade issues on global level may provide an effective push for remanufacturing activities in the EU as demand and supply of cores may change over time. As it has been pointed out in the previous research, e.g.Kalverkamp & Raabe (2018), the complexity of relationships among actors in automotive remanufacturing market may lead to shortage of core supply within the EU. In practice, cores may need to be imported from or exported to countries outside the EU, which due to the current legislative setting may be hindered. Clear international definitions for remanufacturing can be a relevant first step in tackling this issue on global level.

The identified category regarding remanufacturing on product level show that quality certifications and standards may not necessarily have impacts on customers' choice. The warranty is more effective on customers' decision-making and the warranty mainly assures them of the quality. This finding has also been addressed in previous research by Milios & Matsumoto (2019). Quality certifications and standards are general topics and may not necessarily relate to remanufacturing or CE. However, they can affect remanufacturing due to product liability issues. Lack of consistent standards and certifications may result in difficulties particularly when the remanufacturer is a third-party (independent actor) and not the OEM. Similarly, issues related to patents and proprietary rights do not create legal barriers as long as an OEM owns remanufacturing operations internally. Intellectual Property Rights (IPR) issues may however hinder remanufacturing for third-parties due to their liability to OEMs which allows a limited degree of modifications that can be performed on used parts. The challenges related to patent infringements may result in fewer independent actors in the remanufacturing market. While such protections are useful to protect the automotive products in terms of safety and functionality, they may also influence the innovation and competitiveness of the market and therefore should be considered by policymakers, as also suggested by (Kalverkamp & Raabe, 2018).

The findings together with previous research by Guidat et al. (2017) and Karvonen et al.(2017) indicate that remanufacturing has not been addressed, or has only been mentioned vaguely within current EU policies. This can also be associated with the lack of clear definitions for remanufacturing which has been discussed earlier. The absence of clear legal definitions makes it challenging to implement measures such as remanufacturing targets. Addressing automotive remanufacturing through e.g. clear legal definitions in the ELV directive and remanufacturing targets can result in a more effective implementation of CE. Such targets can support remanufacturing of used automotive parts rather than recycling practices.

The different views regarding the promotion of remanufacturing through financial incentives such as taxation are an indication that there are both advantages and disadvantages. They may be effective in increasing companies' motivation to engage in remanufacturing operations; however, they may also result in an imbalance in the market. To illustrate this, two scenarios can be considered: Scenario 1: The OEM is remanufacturing its own products. In this case, tax incentives may result in favouring remanufactured parts over new parts, which in turn can concern OEMs regarding cannibalization of their new parts. If the price difference between remanufactured and new parts are significant, cannibalization can lower the revenue for the OEM. Scenario 2: The remanufacturer is an independent actor (third-party). In this case, the independent remanufacturer gains a price advantage over the OEM. Although this scenario may promote remanufacturing, it may also influence the competitiveness and profitability of the OEM, which has an essential function as a core supplier for the remanufacturing business in this scenario. Thus, policies creating incentives need to consider the risks and implications for all actors on the market and therefore should be carefully formulated.

The results also highlight the importance of customer preferences and their awareness regarding the sustainability benefits of remanufactured products. In doing so, policies can be effective in obliging the sellers e.g. workshops in making remanufactured products available to consumers. Similar policies have been implemented, for instance, in France where it is mandatory to provide customers with an option to choose between remanufactured and new parts. Policies making remanufactured products mandatory in public procurement can also be effective in promoting remanufacturing industry. As also suggested by (Milios, 2018) and (Hartley et al., 2020), such policies can extend the role of public authorities from involvement only in policy making further to influence the market by increasing the demand for the sustainable products.

6.2.1. Implications

Overall, the themes discussed above can be indications that automotive remanufacturing may not necessarily be hindered by particular legislations. The legal obstacles seem mainly based on a lack of policies creating adequate clarifications and incentives for remanufacturing. Specific adjustments in the current policy landscape can be effective in upscaling remanufacturing towards more of a mainstream business. For a better outcome, a combination of policy interventions, or policy mix as suggested by Rogge & Reichardt (2016), can be applied where there is a synchronization between different policy elements and instruments. In order to facilitate the implementation of CE through remanufacturing, the characteristics of such policies, particularly consistency, coherence and comprehensiveness of CE policies, can be improved.

In order to create consistency among policy elements, it is required that the policy elements are aligned and there are not any contradictions between them. In doing so, the sustainability benefits of remanufacturing and its contribution to CE need to first be determined and recognized similar to other actions such as reuse, recycling, and recovering. Clear legal definitions related to remanufacturing are then required to place remanufacturing in the waste hierarchy. For this purpose, instruments such as setting remanufacturing targets are necessary to ensure that a certain share of used automotive parts is actually remanufactured.

In order to create coherence among policy processes, it is necessary that there is a synergy among policy processes and solutions when put into practice, moving in parallel towards the same objective. If the goal of the policy is to increase remanufacturing in automotive industry, policy processes related to shipment of goods across-border need to be revised on a broader level, i.e. international level, in order to identify and remove barriers. When implementing policy solutions such as introducing financial incentives and reduced taxations, their synergy with other solutions need to be considered so that they do not create imbalances among automotive ecosystem actors by favouring individual companies. In policy processes related to remanufacturing, the impact of customer awareness and access to the remanufactured parts should also be taken to account since the increase in demand can directly influence the supply of remanufactured products.

In order to ensure comprehensiveness among policies, it is necessary that the policies are broad and cover all relevant markets, barriers and drivers. Findings have pointed out the same policy for remanufacturing market (e.g. reduced taxations on remanufactured products) may have different impacts on different actors in the value chain and as a result influence the competitiveness of the market. Similarly, different opinions related to possible barriers in transportations of remanufacturing goods within the EU indicates that the levels of obstacles may vary for different actors depending on their position in the value chain. Therefore, the comprehensiveness of current policies relevant to remanufacturing can be improved by considering such differences in designing policy elements addressing remanufacturing.

6.3. Summary of identified legislative barriers and adjustments for the two industries

Table 5 summarizes the identified themes of legislative barriers related to CE in the two industries within the scope of this study. It also briefly summarises potential adjustments based on policy mix characteristics to improve consistency, coherence and comprehensiveness of the legislations. As can be seen, the most frequently addressed legislation improvements are associated with the directives on WEEE, waste, and ELV, which indicate their relevance to the identified legislative barriers related to adoption of CE in the two industries. For service-based CBM in the white goods industry, the main legislative adjustments are regarding establishing measures, which can facilitate the implementation of the waste hierarchy in practice, i.e. prioritization of reuse over recycling. For remanufacturing in the automotive industry, the main legislative adjustments are related to establishing legislations aiming at supporting remanufacturing. Such legislation would stimulate harmonized standards and definitions related to remanufacturing processes and products.

Table 5. Summary of identified themes of legislative barriers for white goods and automotive industry including policy mix characteristics and potential adjustments

Industry	Identified themes	Policy mix characteristics and suggested adjustments		
		Consistency	Coherence	Comprehensiveness
White goods industry	▪ Issues related to cross-border service offers ▪ Uncertainty in classification of pay-per-use business model ▪ Uncertainty in evaluation of service-based business model ▪ Lack of appropriate tax incentives ▪ Immature infrastructure for collection of used appliances ▪ Prioritization of recycling over reuse in EoL strategies ▪ Ununified repair and spare part supply requirements ▪ Complications in cross-border logistics in returning used products	- Create incentives in line with waste hierarchy to avoid prioritizing recycling over reuse (directive on WEEE and waste) - Set separate target rates for reuse and recycling (directive on WEEE) - Align guidelines and standards on reuse and repair of EoL appliances to reflect waste hierarchy (directive on waste and WEEE)	- Ensure current legislation is compatible with the lifecycle approach (directive on WEEE and waste) - Adjust EPR policy to encourage circularity from a lifecycle perspective, not only EoL (directive on WEEE) - Adjust EPR through new incentives to encourage direct involvement of actors in EoL phase to increase reuse instead of recycling practices (directive on WEEE)	- Take interests of established manufacturers and newly formed service-providers into account when transitioning to circular business models - Consider and align legislation from EU, national and local level in different member states (directive on services)
Automotive industry	▪ Lack of clear EoL definition for used parts ▪ Challenges in trade and cross-border logistics ▪ Issues of quality certifications and standards ▪ Risk of patents and property rights infringementLack of remanufacturing targets ▪ Lack of appropriate tax incentives ▪ Limited customers awareness and market availability	- Determine clear legal definitions for remanufactured products and remanufacturing processes (directive on ELV) - Establish remanufacturing as a distinctive EoL strategy besides reuse and recycling with a dedicated remanufacturing target (directive on ELV)	- Revise current legislation to facilitate shipment of cores (directive on Waste) - Establish financial incentives considering its impacts on the automotive market to avoid imbalances - Improve customer awareness and facilitating their access to remanufactured parts	- Revise current legislations while considering interests of established OEM networks and third-party remanufacturers

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