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CICERONE
Circular economy platform for European priorities strategic agenda

Overview report on definition and concept of the Circular Economy in a European Perspective

Authors : Mrs. Bettina BAHN-WALKOWIAK (Wuppertal Institute), Henning WILTS (Wuppertal Institute), Wolfgang REIMER (GKZ), Mengchun LEE (GKZ)

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Author(s)	Mrs. Bettina BAHN-WALKOWIAK, Henning WILTS (Wuppertal Institute), Wolfgang REIMER (GKZ), Mengchun LEE (GKZ)
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Summary

On the basis of a literature research, this subtask develops a conceptional framework for a common understanding of CE within the project team and for the following work packages and tasks. After a brief introduction into the objectives and the context of a circular economy, a more elaborated look into the necessity of an explicit understanding of CE, the objectives, the spatial perspective of CE and the specific challenges within the CICERONE context will be done, in order to develop a basis for a common understanding within the project context. Circular economy can and has to be understood as an (eco-)innovation agenda. Therefore, the paper investigates the role policy has to play to support innovation for a CE transition, for creating the framework conditions and why CE has also to be build from the ground up. Finally, the paper looks from two perspectives at emerging trends and business models in a CE to sketch next steps towards the transition in a selection of central sectors. Conclusions are drawn on the basis of the insights gained by the preceding chapters.

Approval

Date	By
2019-05-20 15:33:27	Dr. Jean-francois RENAULT (FZJ)
2019-05-20 15:34:26	Mrs. Cliona HOWIE (CKIC)

TABLE OF CONTENT

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 820707.

Tables

Figures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 820707.

EXECUTIVE SUMMARY

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After a brief introduction into the objectives and the context of a circular economy, a more elaborated look into the necessity of an explicit understanding of CE, the objectives, the spatial perspective of CE and the specific challenges within the CICERONE context will be done, in order to develop a basis for a common understanding within the project context.

Circular economy can and has to be understood as an (eco-)innovation agenda. Therefore, the paper investigates the role policy has to play to support innovation for a CE transition, for creating the framework conditions and why CE has also to be build from the ground up.

Finally, the paper looks from two perspectives at emerging trends and business models in a CE to sketch next steps towards the transition in a selection of central sectors.

Conclusions are drawn on the basis of the insights gained by the preceding chapters.

KEYWORDS

Circular economy, eco-innovation, circular business models, objectives, critical raw materials

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1 INTRODUCTION, OBJECTIVES AND CONTEXT

The CICERONE project brings together programme owners, research organizations and other stakeholders to create a platform for efficient Circular Economy programming. The priority setting and the organization of the future platform is driven by Programme Owners (POs), involved either as project partners, or via a stakeholder network.

Within the project, WP 1 aims to generate an understanding for CE in terms of its societal challenge, industrial relevance, R&I policy, and trends in technology developments using as far as possible relevant available reports (e. g. from various EU-funded projects Circular Impacts, SCREEN, MIREU, CRESTING, FUTURING, SCRREEN, and others). It compiles and analyses the status quo regarding the emergence of circular economy and affiliated strategies and policy making in a European Union context.

The key objective is to assess how CE is being implemented at regional level, e.g. via the RIS3 strategy and Structural Funds. As such it sets the scope for the project and provides the background against, which programmes and measures can be understood, assessed, developed and recommended in succinct tasks and work packages.

Against this background, this first deliverable is a short overview paper on CE in a European context. It provides a common conceptional understanding of circular economy and highlights trends in technology and business field developments.

Based on this common understanding, WP 1 will continue to carry out an initial benchmarking exercise for a deeper understanding of the state of the art, mapping stakeholders, existing RDI priorities as well as funding and legal mechanisms. A prioritisation methodology will be developed to support an analysis of the current performance: synergies, gaps and duplications will be characterised, and pathways for improvements will be formulated. Identified best practices will drive the definition of policy recommendations.

Once the state of the art has been clearly mapped out, the actual prioritisation work will be carried out. This includes building a Strategic Research and Innovation Agenda (SRIA), performing an ex-ante impact assessment of joint programming on circular economy R&I, and developing a policy toolkit to promote the priorities and foster adoption by policy-makers. The project will also set the grounds for the future PO platform, starting with defining its strategic role in the existing landscape. The next step will be to specify governance and possible legal frameworks, as well as creating a financially sustainable model. It is a key objective that the platform be sustained after the end of the project.

This specific deliverable is structured as follows: Chapter 2 will discuss the relevance of a shared understanding what is actually meant by a circular economy and how this is addressed within CICERONE. Chapter 3 focuses on CE in the context of innovation processes in different business fields, the final chapter draws preliminary conclusions for the further work in CICERONE.

2 UNDERSTANDIG CIRCULAR ECONOMY

2.1 Necessity of an explicit conceptional understanding of CE

Despite the growing academic literature on the circular economy, the theoretical foundations for a shared ground of knowledge or a set conceptional model have not been established yet (see e.g. Kalmykova et al., 2018; Prendeville et al., 2018). It is generally accepted that this area of research is still in a consolidation phase in terms of definition, boundaries, principles and associated practices

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(Korhonen et al., 2018b, Merli et al., 2018). This also holds for the understanding of how complex socio-economic systems and sub-systems may affect and be affected by the so-called 'circular-economy transitions' (Korhonen et al., 2018a). A recent publication highlighted that in the scientific literature alone more than 100 definitions of a circular economy can be differentiated (Kirchherr et al., 2017).

It is important to take into account that this broad variety of definitions – from very academic, complex models to often simple and pragmatic visualisations – is linked to an frequently very diverging understanding of the objectives of becoming circular. Against that background, measuring progress towards circularity requires as a crucial first step an explicit understanding of the objectives and the rationality of a circular economy – otherwise the development of indicators as well as the monitoring of these indicators might completely overlook the actual relevant trends and developments. The overview on existing indicator frameworks by Kirchherr et al. (2017) very clearly highlighted that the robustness or accuracy of specific indicators can only be assessed with a clear conceptional understanding of a circular economy and its objectives that also allows to develop a specific hierarchy of targets and indicators, e.g. in the case of trade-offs. The aspired transformation of our patterns of consumption and productions will require a complex systemic change that will have to take into account all sorts of intended or un-intended side effects, variables and causal links as illustrated in Figure 1. Success or failure of this change process will depend on a clear and shared idea of its overall objectives.

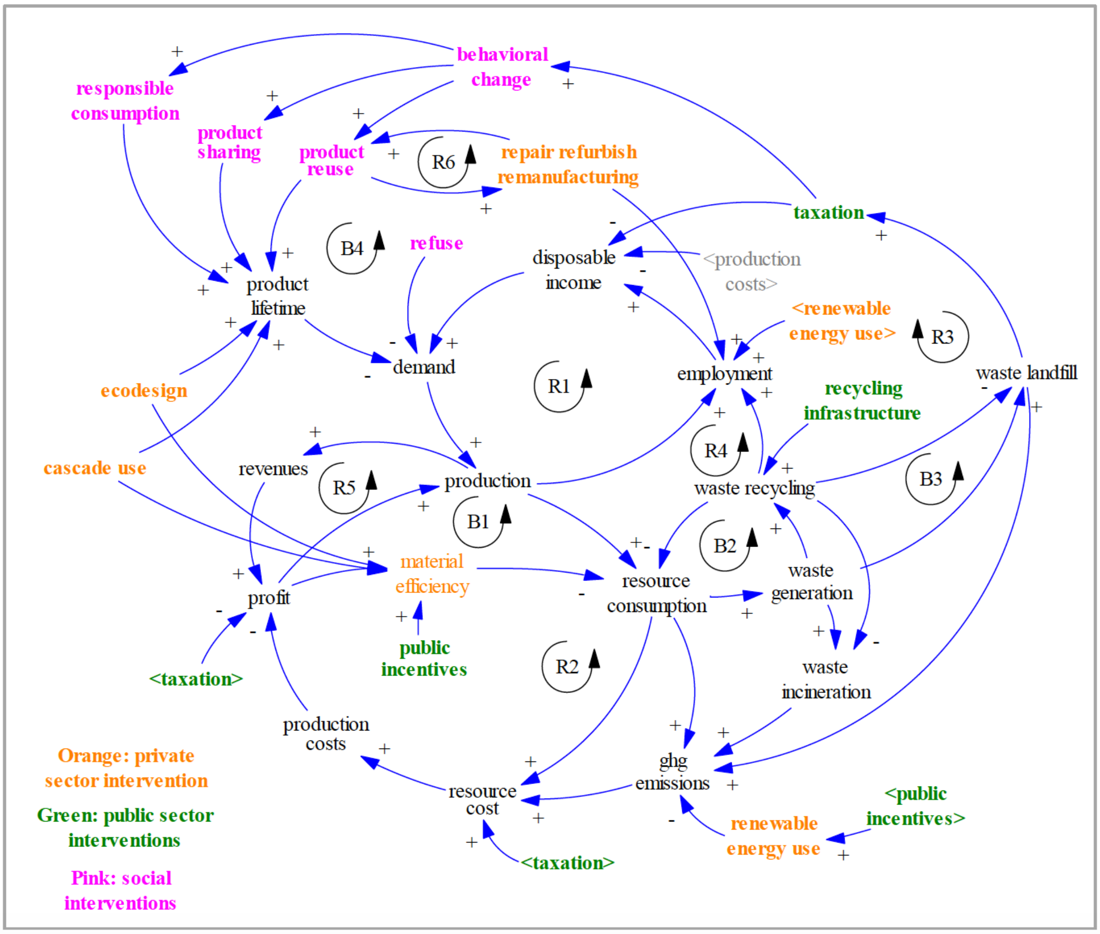

Figure 1: Causal loop diagram for the circular economy and its interlinkages (ESPON, 2018).

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2.2 Objectives of a CE

Following the different definitions and conceptionalisations of a circular economy, different analytical categories have to be differentiated in order to gain an explicit understanding of the objectives to be achieved in a more circular – or if that´s even possible – completely circular economy.

Most importantly it has to be noted that the overall strategic objectives can but does not have to include aspects of environmental, economic and social objectives. The starting point for most definitions is an environmental rationale to protect natural resources, to avoid environmental burdens to ecosystems, species and thus indirectly also to avoid negative impacts on human health. Most concepts focus on the output-side of the socio-economic metabolism – the waste streams and their disposal and recovery – as well as on the input-side, measured e.g. by material-flow based indicators like domestic material consumption. Increasingly also the potential contributions to climate change mitigation by circularity are seen as a strategic objective (Material Economics, n.d.).

Despite this focus on the environmental benefits of the circular economy, it should be noted that e.g. the Circular Economy Action Plan by the European Commission has been initiated primarily by DG Grow and has a clear focus on the cost savings, job creation and competitiveness potentials (European Commission, 2015):

"The circular economy will boost the EU's competitiveness by protecting businesses against scarcity of resources and volatile prices, helping to create new business opportunities and innovative, more efficient ways of producing and consuming. It will create local jobs at all skills levels and opportunities for social integration and cohesion. At the same time, it will save energy and help avoid the irreversible damages caused by using up resources at a rate that exceeds the Earth's capacity to renew them in terms of climate and biodiversity, air, soil and water pollution. (...) Action on the circular economy therefore ties in closely with key EU priorities, including jobs and growth, the investment agenda, climate and energy, the social agenda and industrial innovation, and with global efforts on sustainable development."

Obviously environmental objectives on the one hand and economic objectives on the other can be very well aligned – this is the unique opportunity of the circular economy as e.g. illustrated by the assessments published by the Ellen MacArthur Foundation (Ellen MacArthur Foundation, 2017). Nevertheless it has to be stated that these co-synergies are not an automatic and necessary must – but have to be ensured by an appropriate regulatory framework! Trade-offs can be imaginable on many different levels, e.g. lowering the technical thresholds for pollutants in recycled plastics could definitely lead to new business opportunities but at the same time pose severe risks to the health of consumers. From a more conceptional point of view the circular economy often has a clear emphasis on the consistency of our socio-economic metabolism – neglecting the need for an absolute reduction of the natural resource requirements of our industry (UNEP, 2017). Looking at the mostly positively connoted image of the "circle", its overall long-term sustainability will depend not only on its closure but also on the total amount of resources that will be necessary to keep it floating. CE indicator frameworks from the global down to the urban level will have to ensure that these aspects are comprehensively covered, e.g. by not only focussing on recycling rates and neglecting waste generation.

Other important analytical dimensions e.g. include the temporal perspective with a majority of indicators focussing on current data, looking at improvements of the status quo compared to the past. A very different set of indicators in contrast has a focus on future developments, measuring e.g.

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eco-innovation potentials in terms of R&D expenditures or based on patent analysis (O'Brien et al., 2018).

2.3 Spatial perspective

Starting point of the CIRCTER project have been the specific challenges of a spatial perspective on the circular economy: the regulation of local circuits and the relational logic of geographical norms and scales as factors for circular economy development remain very little discussed for the moment (Barles, 2009). In our view, three key analytical challenges need to be sorted out to characterise the circular economy under a territorial perspective, namely: (1) the scales of operation of circular economic systems and sub-systems; (2) the territorial factors that may affect the development of closed material and energy loops, and; (3) the territorial outcomes that might derive from the penetration of Circular Business Models (CBM) at various levels.

Regarding the first challenge, we argue that the circular economy can be characterised and studied at different scales depending on the specific sub-systems that are considered, which are also tightly linked with the notion of 'organizational width'. The circular economy clearly has a multi-scalar expression that should be analysed beyond the borders of single companies, cities, regions or countries. At national and global levels (macro scale), this can be done by e.g. focusing on the geographies of international supply chains and globalised waste flows (Clapp, 2001, Velis, 2015). Some argue that intermediate regional areas (meso-scale) may be the most suitable level for closing material loops and creating sustainable industrial ecosystems (Sterr & Ott, 2004). But the circular economy also has an expression at the urban and local levels (micro-scale). Here is where the circular economy can be materialised in very tangible initiatives, for instance in the form of local food systems or closed circuits of secondary materials of the lowest value (e.g. demolition materials or organic wastes). In any case, the debate on the territorial definition of a circular economy goes well beyond the delimitation of scales of operation based on administrative-unit boundaries. In fact, the identification of the scales of operation ultimately links to the definition of appropriate system boundaries for the characterization of circular economies at various territorial levels.

These somehow theoretical considerations become very concrete when it comes to the assessment of imports and exports of materials as well as waste streams: The circular economy is often conceptionalised as a self-sufficiency approach where the reliance on raw material imports is reduced, as e.g. illustrated in the following schematic CE figure by the European Environment Agency that explicitly states that for a circular system material imports and waste exports should be minimized.

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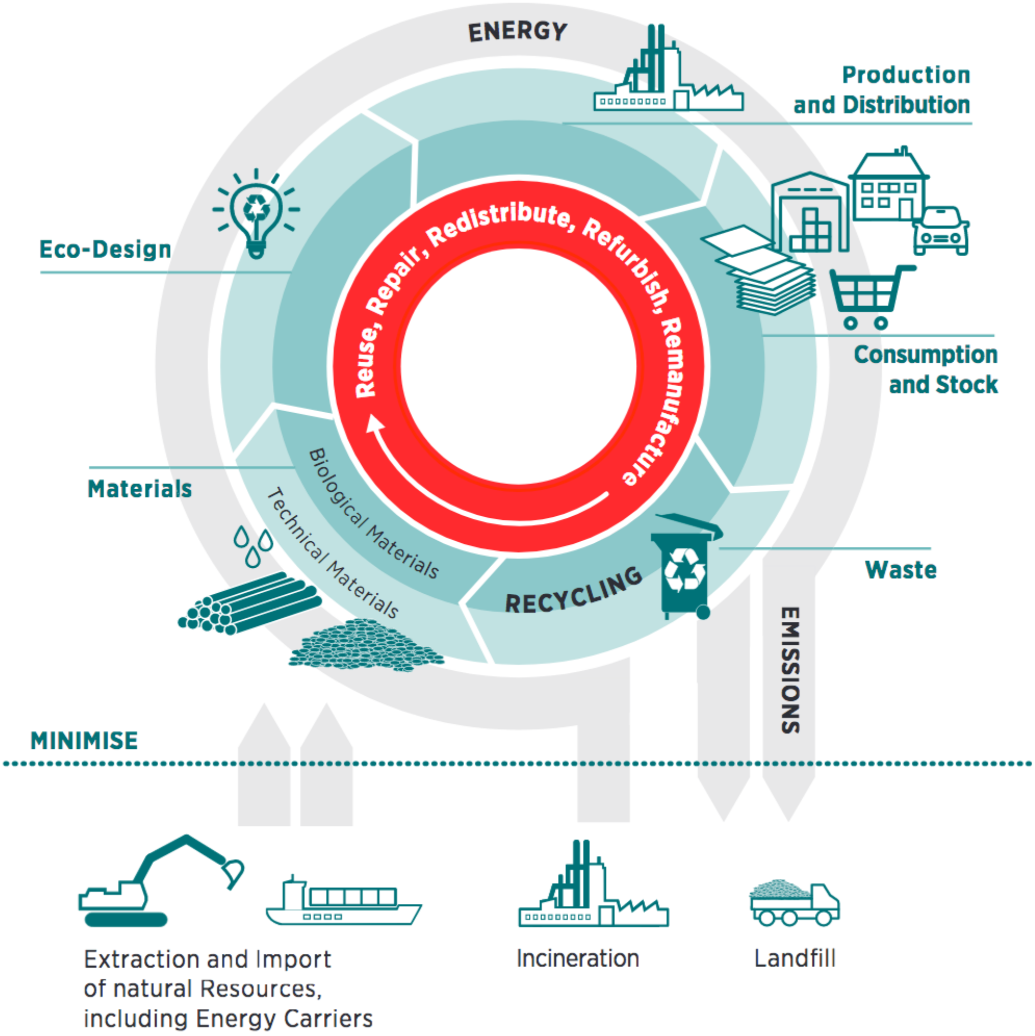

Figure 2: The Concept of Circular Economy (Wilts & Berg, 2017)

From an environmental point of view such approach aims of course to reduce a simple shifting of burdens to other regions of the world, e.g. by disposing residual waste in countries with lower environmental standards as highlighted by the Chinese ban of low quality waste imports.

At the same time the strict self-sufficiency approach also bears the risk of neglecting relevant territorial factors as outlined above: If one region has established high quality waste treatment infrastructures – why shouldn´t it import waste from regions without appropriate technology where waste would e.g. just landfilled.

The second important aspect is of course the spatial scale chosen for the closing of material cycles: The assessment of recovery rates for example for municipal solid waste would be completely different if calculated on a city level, on an average national level or in contrast on a city quarter level – and despite the completely different results for the same indicator just on different spatial levels, the environmental performance of the system could be exactly the same.

2.4 Specific CE challenges in the CICERONE context

When addressing circular economy, the CICERONE partners refer to a comprehensive scope, in line with the European Commission. This is illustrated in the schematic below.

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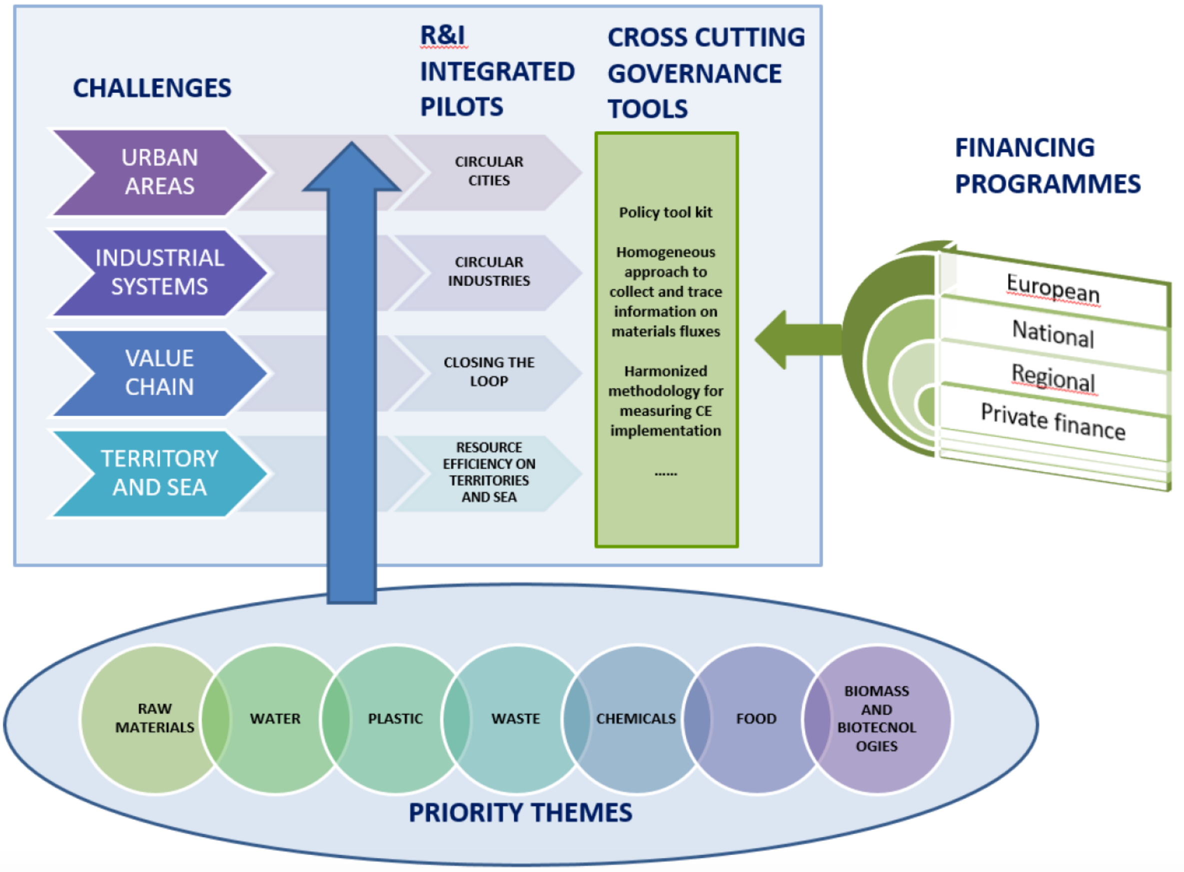

Figure 3: Addressing Circular Economy on CICERONE

The project will address as first priority the definition of joint national and regional funding programmes, complementary to European private finance funding programmes. The following matrix details the main topics of these challenges.

Table 1: Thematic focus of the CICERONE project

Challenges	Addressed topics
Urban areas	Waste prevention and management; Urban water management and reuse; Urban mining; Sharing economy; Prolongation of products life - products reuse; Building; Food waste prevention and valorisation; Citizen awareness
Industrial systems	Eco-design; Product and process eco-innovation; Water cycle; Agroindustry; Metallurgy; Manufacturing; Lean and clean technologies; Chemicals; Industrial Symbiosis, Business models;
Value chains	Eco-design and Product eco-innovation; Value chain traceability; Sustainable consumption; Reuse; Collection; Recycling; Sharing economy
Territory & sea	Marine litter; Material flows; Landfill mining; Sustainable tourism

For these challenges, it aims to develop an innovation-oriented CE approach; with the transition from a linear to a circular economy at its core. Thus the project will go beyond closing the loops of material flows. Circular economy in this context will be aligned with the focus of the European Commission´s

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CE Action Plan as it includes comprehensive commitments on ecodesign, the development of strategic approaches for specific materials. CIRECONE will specifically focus on horizontal enabling measures in areas such as innovation and investment that are included to stimulate the transition to a circular economy: "The proposed actions support the circular economy in each step of the value chain – from production to consumption, repair and remanufacturing, waste management, and secondary raw materials that are fed back into the economy" (European Commission, 2015).

Taking these different aspects and issues into account, the following figure shows an analytical CE framework that goes beyond the rather static perspective of flows but focuses on circular activities, business models and innovations instead.

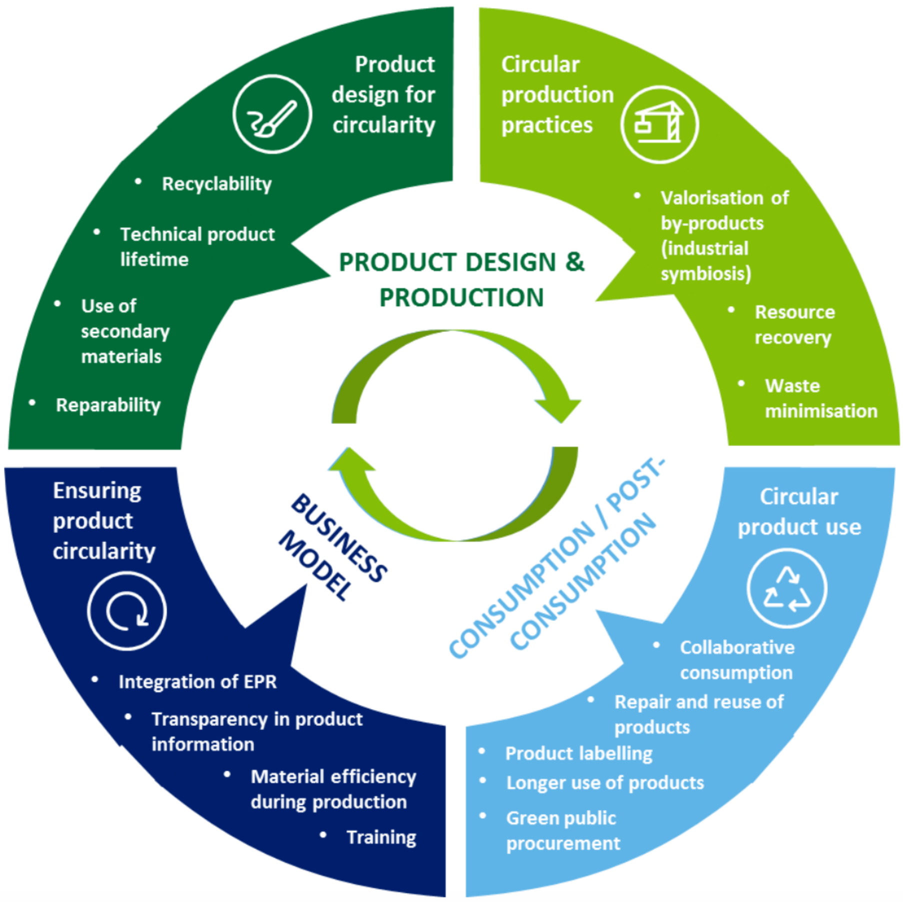

Figure 4: Framework for monitoring and evaluation of product eco-innovation for the circular economy (O'Brien et al., 2018, p. 20)

The framework encompasses three main areas (business model, product design/production and use/post-consumption) and associated indicators that effect the circularity of the system:

- Business model: factors applied in business models to ensure the full circularity potential of a product, e.g. establishment of take back schemes, application of extended producer responsibility (EPR), integration of circular product design and production into business models, etc.
- Product design and production: product design and manufacturing elements that influence the circularity potential of the product from a technical perspective, e.g. durability, reparability, recyclability, type of materials used, efficient production processes in terms of less resources used and waste produced, etc.

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- Use and post-consumption: consumer behaviour elements that contribute towards close-looped product cycles, e.g. innovative consumption models, longer use of products, recycling, etc.

3 THE CIRCULAR ECONOMY AS AN INNOVATION AGENDA

3.1 Introduction

The pace of innovation and technological change is unprecedented today. While many innovations and technological achievements are expected to be helpful in order to strive for the reduction of environmental pressures and progress towards circularity, there is much uncertainty and risk, and many innovations doubtlessly still contribute to accelerating resource use and wastage due to rebound effects.

The current system of production and consumption can be characterised as a predominately linear system – as outlined above as key starting point of the CICERONE project. Resources are extracted, processed, used and disposed as waste. At the end of a products' life cycle wastes are typically incinerated (thermal recovery) or landfilled. In both cases, materials are withdrawn from or eliminated within the economic system, even if some energy is regained through thermal utilisation. Such a linear economic model is able to persist as long as resources are abundant within a world of infinite needs. However, the global demand for resources is still increasing and both non-renewables and also renewables are limited. In the long term, a linear economic model must reach its limits (Wilts 2016).

However, there are a multitude of alternatives approaches to break up the linear path-dependent economy, reduce its resource use, increase its resource efficiency and minimise its generation of hazardous substances and wastes. These are known as the 3 R's: reduce (i.e., decrease the demand and the use of raw materials, intermediates and products); reuse (i.e., reutilisation of products or components of products); and recycle (i.e., feed back substances and materials into the system). All those approaches support a circular economy as a fundamental alternative to the linear economic model (EEA 2015, p. 9, EEA 2016).

Besides the famous 3 R's, further essential elements of a circular economy have been brought onto the agenda as innovative circular business models. These include: refurbish, sharing/leasing, remanufacture, recovery, and repair while reduce (in the sense of waste prevention and minimisation of hazardous substances) plays also a prominent role (European Commission 2014).

The vision is to deploy eco-innovation as a means to reach a resource-efficient circular economy in Europe.

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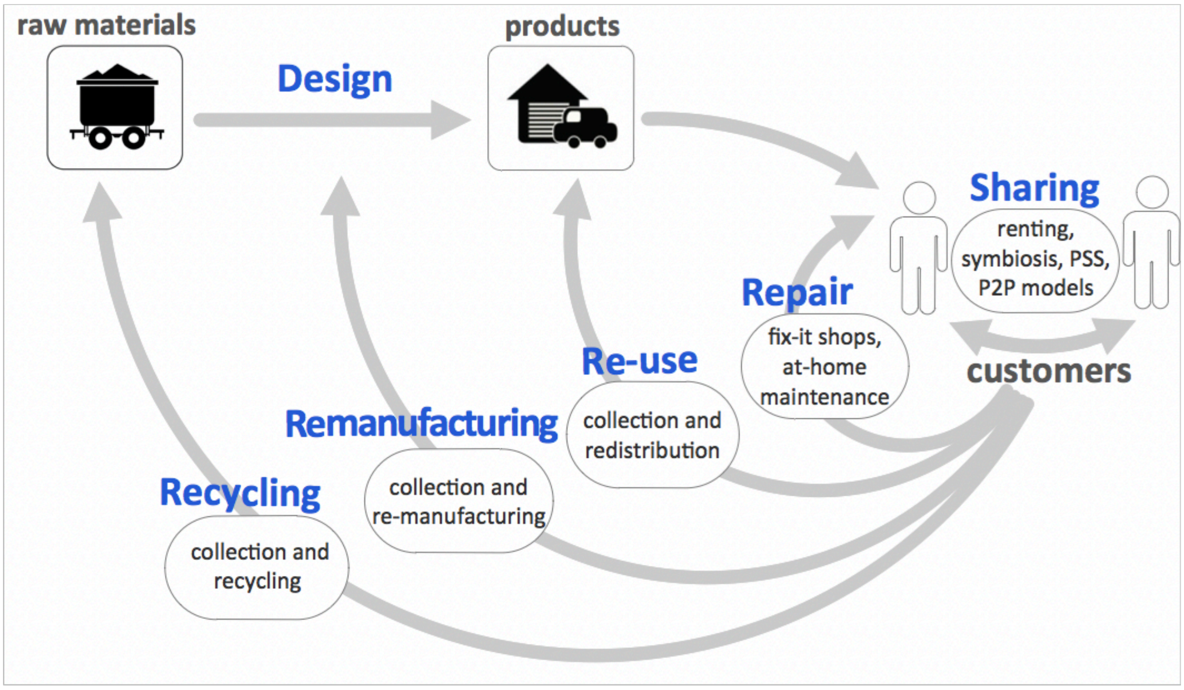

Figure 5: A simplified illustration of a circular economy (Based on EIO 2014, p.4)

The goal of a sustainable resource and waste management must be to ultimately achieve a transition to a fully fledged circular economy within this century (WBGU 2016, p. 85), i.e. to preserve the value of the resources and materials as long as possible, to reuse them as often as possible and, ideally, to generate no or as little as possible waste. The concept includes all sectors of the economy, from resource extraction over the production, storage and consumption, as well as the disposal or recycling. Through the closing of loops waste shall become a resource again (so-called "second-sourcing"). But to implement this idea as extensively as possible, the consideration of reuse, repair, remanufacturing, sharing and recycling is necessary as well as eco-innovation and circular economy aspects in the product design (Wilts 2016). Stronger eco-innovation efforts are needed for each option.

Eco-innovation is a vital element of all circular economy efforts and has been defined as any innovation that reduces the use of natural resources and decreases the release of harmful substances across the whole lifecycle (EIO 2010). Eco-innovations with the potential to enable the transition to a resource-efficient circular economy model span efforts to change dominant business models (from novel product and service design to reconfigured value chains), transform the way citizens interact with products and services (ownership, leasing, sharing, etc.) and develop improved systems for delivering value (sustainable cities, green mobility, smart energy systems, etc.) (EIO 2014, p.8).

Table 2 presents the scope of different types of eco-innovation related to the circular economy. It portrays the wide array of avenues to eco-innovation that may play a role in different aspects of the transformation: for example from changing behaviours to adapting technologies.

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Table 2: Types of eco-innovation for a circular economy

Type	Brief descriptions, examples & keywords
Process eco-innovation	**Material use, emissions and hazardous substances are reduced, risks are lowered and costs are saved in production processes** Advancing remanufacturing, such as - Refurbishment by replacing or repairing components that are defective, including the update of products - Disassembly and recovery at the component, material and substance level - Upcycling, functional recycling, downcycling → Zero waste production, zero emissions, cleaner production
Organisational eco-innovation	**Methods and management systems reorganisation pushing for closing the loops and increasing resource efficiency** New business models e.g. industrial symbiosis, new collection and recovery schemes for valuable resources (incl. Extended Producer Responsibility/Individual Producer Responsibility), → From products to functional services (product-service systems)
Marketing eco-innovation	**Product and service design, placement, promotion, pricing** Promotion of the reuse for the same purpose (e.g. bottles, appliances), promotion of the reuse for different purposes (e.g. tyres as boat fenders, for play grounds) → Eco-labelling, green branding
Social eco-innovation	**Behavioural and lifestyle changes, user-led innovation** Sharing (e.g. domestic appliances, books, textiles), collaborative consumption (e.g. flats, garden tools) sufficiency (e.g. plastic bag bans) → Smart consumption, responsible shopping, use rather than own schemes
System eco-innovation	**Entirely new systems are created with completely new functions reducing the overall environmental impact** Leading to a substantial dematerialisation of the industrial society → New urban governance, smart cities, permaculture

Source: Adapted on the basis of EIO 2014.

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3.2 The role of policy in the circular economy transition: how change can be driven

3.2.1 Framework conditions for fostering the CE

3.2.1.1 CE in a wider policy context

The concept of a circular economy is relatively new at the European level, but the term has been in use for some years, e.g. in China, Japan, and Germany, notwithstanding that those countries have not implemented a fully-fledged circular economy already. In Europe, the circular economy concept has been embedded in a wider policy context referring to the green economy and the strive for a resource-efficient and low-carbon society (see Figure 6 below) (European Commission 2015). As yet, circular economy activities at the Member State level are still overwhelmingly regarded as waste management measures (EEA 2016), which indicates a lack of knowledge and general uncertainty in the transformation to a circular resource management and neglects the eco-innovation efforts in the stage of product design.

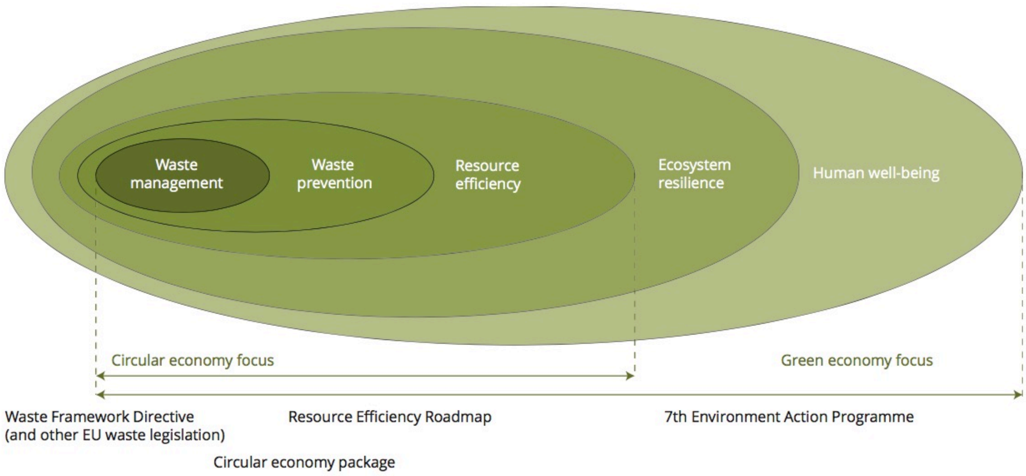

Figure 6: Circular Economy in the Wider Polcy Context (EEA 2016, p.31)

However, eco-innovation and circular economy concepts and activities need to be more closely linked – especially when it comes to R&D programmes. The Waste Framework Directive provides for technical requirements and regulations (e.g. mandatory recycling quota for several waste streams) but, as yet, the institutional settings and the country-specific planning for circular economy issues vary significantly from country to country with regard to contents, ambitions, targets and choice of policy instruments and it mainly focuses on waste management (Bahn-Walkowiak et al. 2014). The following Figure 7 shows where the current policy framework has direct and indirect impacts on the different options and phases of a circular economy.

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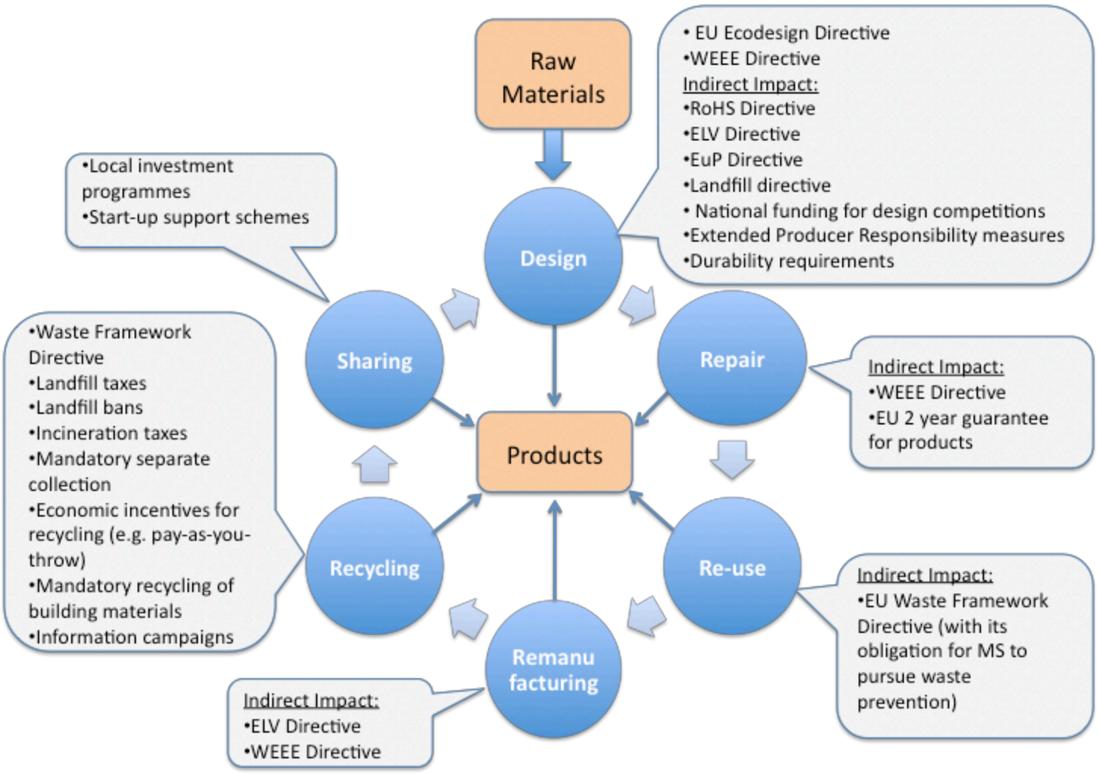

Figure 7: Overview of existing instruments and approaches for a circular economy in EU (Doranova and Gigli 2014)

The EU MS also often lack an integrated infrastructure planning for waste infrastructures, with corresponding counter and side effects on resource efficiency and circular economy. For example, regional waste incineration over-capacities act as an incentive to use those usually capital-intensive incineration plants at full capacity but they do not drive a circular economy. The current diverging country performances concerning waste recycling rates, infrastructures and waste prevention measures in place indicate that—as long as waste is still looked at as a cost factor instead of as a "resource"—regulatory instruments are often more effective than economic instruments (Bahn-Walkowiak et al. 2014).

Policy approaches are frequently not sufficiently considering the waste hierarchy and circular necessities and thus lead to unwanted effects. A policy for diverting waste from landfill without considering an alternative and eco-innovative treatment for a pathway further up the waste hierarchy, which might be environmentally and economically appropriate in the specific context, can lead to results, which:

- are ineffective (e.g. recycling focus on less resource-intensive waste fractions instead of the resource-intensive ones),
- induce unwanted pathways (e.g. investment in capital-intensive incineration capacities without taking account of future shifts such as recycling) or
- have a completely counterproductive effect (e.g. illegal dumping).

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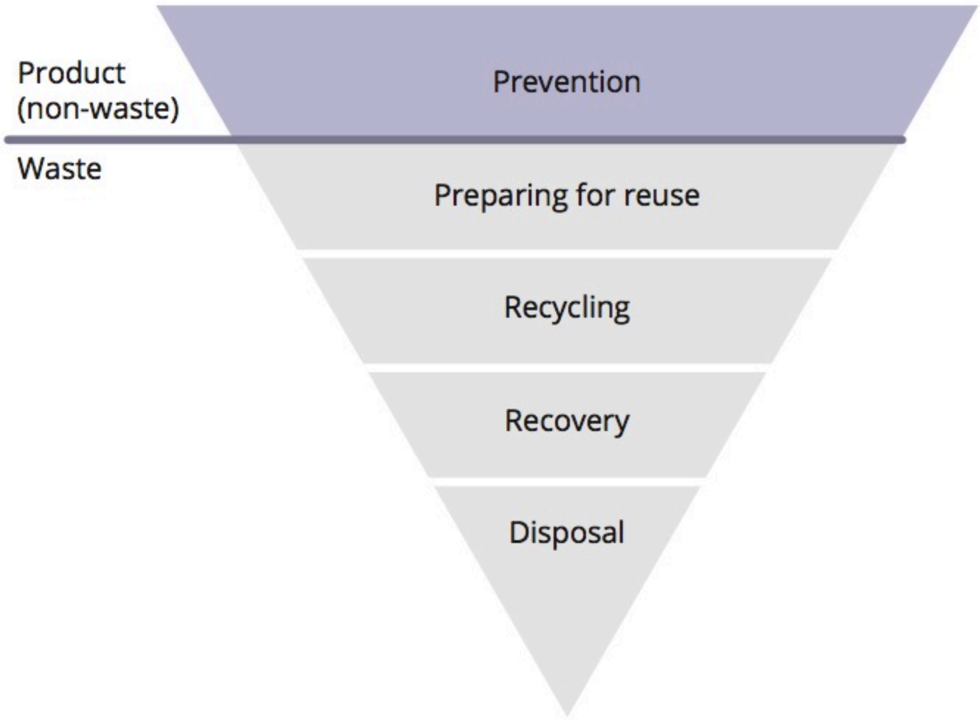

Figure 8: Waste Hierarchy (The European Parliament and the Council of the European Union 2008).

3.2.1.2 Barriers to a better circular performance

While the benefits are increasingly recognised, there are many barriers to the transition to a circular economy indicating investment in a series of necessary measures at the same time:

- Insufficient **investment** in recycling and recovery infrastructure, and eco-innovation and eco-technologies for closing the loops;
- Insufficient **skills and investment** in circular product ecodesign and production which could facilitate greater re-use, remanufacture, repair and recycling;
- Challenges in obtaining **suitable finance** for eco-investment;
- Current levels of **resource pricing** create economic signals that do not encourage efficient resource use, pollution mitigiation or innovation;
- Limited **consumer and business acceptance of potentially more efficient service oriented buisness models**, e.g. leasing rather than owing, performance-based payment models;
- Insufficient **waste separation at source** (e.g. for food waste, packaging);
- Lack of incentives due tot he insufficient **internalisation of externalites** through policy or other measures;
- Limited **information, know-how and economic incentives for key elements in the supply and maintenance chain**, e.g. for repair and reuse, on chemical composition of certain products such as substances in electronic devices;

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- Limited **sustainable public procurement** incentives in most public agenices (i.e. Green Public Procurement);
- Non-**alignment of power and incentives between actors within and across value chains** (e.g. between producers and recyclers) to imrpove cross-cycle and cross-sector performance;
- Shortfalls in **consumer awareness** (e.g. perishability of food products);
- Weaknesses in **policy coherence at different levels** (e.g. bioenergy and waste policies) (adapted from European Union 2014)

A circular economy will need to address all stakeholders for such fundamental transition: businesses, citizens, civil society, and governments (EEA 2016) as well as take different action at the EU, national, regional and local levels.

3.2.1.3 Key actors in building a CE

Implementing policies towards building a circular economy model requires the participation of many different types of stakeholders. This is particularly true for implementing a coherent strategy, when a wide range of actors should be involved, including national/regional/local governments, local businesses, NGOs, social enterprises, consumers/citizens, academic and research centres. Diverse roles and potential inputs by diverse stakeholders are summarised below.

Table 3: Key actors to be involved and their role in promoting circular economy

National, regional, local authorities and agencies dealing with industrial development and waste • Ensuring policy, regulatory support, introduction of support measures, as well as technical and financial support • Facilitating the dialogue with, and between, research organisations, businesses and civil society organisations • Leading, or involvement in, project development, implementation, monitoring of project activities and the financial allocation • Supporting awareness raising and education amongst the population and promoting more sustainable lifestyle, sharing, re-use, recycling
Businesses and industries • Developing and investing in new sustainable businesses, business models, products and services based on circularity principles, symbiosis • Cooperating with authorities in implementing initiatives and helping to scope visions for the greening and circularity in regions, cities and communities • Cooperating with research organisations in developing new eco-innovative and circular solutions
National, regional or local innovation agencies and intermediaries • Advising SMEs and organisations on innovation measures • Advising or playing an active role in the development and implementation of projects and monitoring project activities, outcomes and impacts

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- Cooperating with authorities in implementing eco-innovation initiatives and scoping visions for the greening of regions, cities and communities
- Promoting or lobbying for specific regulations or policy decisions

Research organisations, cluster organisations and universities

- Cooperating with authorities in implementing sustainable initiatives and helping to scope visions for the greening and circularity of regions, cities and communities
- Cooperating with SMEs and industries in developing new solutions
- Facilitating or taking an active role in project development and implementation, and the monitoring of project activities, outcomes and impacts

NGOs, citizens, user groups

- Participating in priority setting for eco-innovation initiative planning
- Educating and raising awareness amongst the population and promoting social innovations in areas such as lifestyle and mobility
- Supporting project planning, implementation and monitoring
- Creating networks and mobilising local efforts
- Lobbying for specific regulations or policy decisions
- Co-creating and co-testing of new eco-innovations by users, NGOs, citizens, user groups
- Supporting the dissemination of eco-innovations towards a circular economy
- Supporting eco-innovative or sustainable systems such as recycling, eco-mobility and sustainable lifestyle

Source: Based on Doronova and Gigli 2014.

For all those stakeholders, circular economy will have different meanings and involve different approaches and responsibilities. This requires a systemic approach that “makes use of a wide toolkit of policies and measures, across different points of value changes and affecting the full set of private and public stakeholders. Given the multi-level governance approach needed, options can be structured across different actors (e.g. EU, Member State, regional and local authorities, private sector, civil society, citizens), levels and timeframes, keeping in mind that in some areas circular economy benefits will materialise as a result of own initiatives by the private sector, while in other areas support (including public intervention) will be needed to encourage transitions” (European Union 2014, p. 54).

3.2.2 Building a CE from the ground up

Grounded on the idea that the circular economy transition will be powered by a combination of bottom-up and top-down changes, eco-innovation can transform individual behaviour and also create new forms of interactions between people or change peoples’ relationship with products.

The transformative potential of cities and urban regions, for example, is important at different levels by contributing to a sustainable development and in practice by a multitude of circular economy relevant approaches, like initiating and running repair cafés, sharing, reuse and refurbish initiatives,

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and promoting waste prevention approaches, etc. which are, first and foremost, implementable at local levels (Maschkowski and Wanner 2014). At present, this is a niche development mentioned here in order to illustrate the ideas of bottom-up initiatives. As an organisational innovation in businesses re-manufacturing, repair, maintenance, recycling and eco-design can however create business opportunities for SMEs and “have a great potential to become drivers of economic growth and job creation while, at the same time, making a significant contribution to addressing environmental challenges” (European Commission 2014).

This section briefly shows different types of eco-innovation that play a role within a circular economy for future citizens *and* businesses and provides good practice examples from the country reports. A social (and sometimes user-led niche innovation) can induce behavioural and lifestyle changes that are more sustainable than existing solutions and thus “reduce impacts on the environment, but also re-structure social relations in one form or the other” (EIO 2013).

3.2.2.1 Re-use, sharing and collaborative consumption

Re-use is a critical part of the 3R waste management strategy (reduce, reuse, recycle) and eco-innovation can play a central role in enabling re-use, sharing and collaborative consumption. From the product perspective, re-use relates to aspects like longevity, durability, and reparability, and thus closely links to product design. Social eco-innovation such as sharing and collaborative consumption, often induced by user-led social eco-innovation and new business models, emerge as particularly relevant. Re-use is linked to social enterprises as well as citizen movements and relates to changes in consumption and disposal behaviour. This can play an important role notably in eco-innovative business models based on service provision and is instrumental in models based on sharing, leasing and product-service systems, which require extensive use of goods by multiple users and increase the need for regular maintenance and repair, be it commercial or non-commercial.

3.2.2.2 Repair and maintenance

Repair[1], maintenance[2] and remanufacturing[3] can be characterised as service innovation activities prolonging the lifetime of products which allow avoiding buying new replacements, thus preventing pollution, dispensable material use and waste arising. There is significant potential to develop innovative approaches to providing maintenance and repair services in the EU. However, the role of repair and maintenance has not been explored sufficiently in relation to eco-innovation, nevertheless their role in service based eco-innovative business models (based on sharing, rental, product-service systems) can be significant.

Integrating repair services in the product can provide a competitive advantage for a company and repair based business models can offer extended business opportunities for product suppliers. There are also some practices where producers provide lifetime guarantees and repair services for their product, which can be seen as a part of the business model. These products are normally “high end” products, however there are also examples relevant to “average consumers”. There is a close link to eco-design that has to allow for repair and maintenance.

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[1] Repair (refurbish, reconditioning) is defined as a correction of a specified fault in a product/component and returning it to

[2] Maintenance has a wider scope than ‘repair’ and it is defined as a critical activity carried out in the use phase of the product life cycle to prolong system availability. Maintenance offerings can include repairs, servicing, diagnostics (onsite and remote), technical support (documentation and personal), installation, warranty, courtesy replacement product whilst product is being repaired, cleaning/valeting (http://circulareconomytoolkit.org/about.html).

[3] refers to used product that after the remanufacturing process is as good as a new one; so includes even upgrading.

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3.2.2.3 *User-led eco-design*

The concept of eco-design has a focus on the environmental impacts of products during their whole life cycle and aims to offer new solutions that are profitable and attractive but lead to an overall reduction in the consumption of materials and energy at the same time (EIO 2014). In addition to that, user-led eco-innovation is driven by customer demands for new goods and services or developed with stakeholders, thereby minimising the risk of superfluous product features or functionality.

The concept of eco-design has been evolving from a focus on single aspects of the product, like energy consumption, to a more holistic, life-cycle approach. This is a clear link to the circular economy model as it means that each phase of the product life cycle—including raw materials, production, distribution, use, re-use, re-manufacturing, recycling and disposal—is taken into consideration in the design of a product. In practice, however, the application of the concept is still rather narrow: while energy performance has become a standard element of a wide range of products (home appliances, vehicles, etc.), life-cycle thinking has only been applied to a limited number of examples and has not, yet, broken out of niche markets (EIO 2014).

3.2.2.4 *Mix of policy measures to support circular economy on national and local level*

Introducing rightly chosen and designed policy measures can motivate or regulate resource efficiency, waste reduction, recycling, re-use, and remanufacturing, and create demand for sustainably designed products as well as resource saving services. There is a need to directly support resource saving and eco-innovation in SMEs, as underlined by the Green Action Plan for SMEs "thus supporting green business developments across all European regions, notably in view of the fact that, at this stage, significant differences in resource efficiency exist between sectors and Member States" (European Commission 2014).

The scope of policy measures to support eco-innovations for circular economy, resource saving, and sustainable design can be quite wide. Many traditional innovation support measures can be adapted to support eco-innovations based on circularity. The figure below presents policy measures that can be adopted to support circular economy objectives.

Table 4: Examples of national and local policy measures to support circular economy

Categories of policy measures	Examples of policy measures
Regulatory instruments	• Regulations (e.g. on waste recycling, extended producers responsibility, eco-design, take-back, transparency in material chain and responsibilities, etc.) • Quality and other mandatory targets (e.g. waste recycling, re-use) • Codes, standards, certification for products, recycled material content, packaging, emissions, as well as the ones triggering innovation prior to setting new minimum performance limits
Economic instruments	• Fiscal/financial instruments and incentives, including, charges and taxes for waste, incineration, landfill, subsidies and tax reliefs, pay as you throw • Direct investment/funding (e.g. infrastructure, programme, etc.) • Demand pull instruments, including public procurement • Market based instruments, etc.

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Research, development and deployment	• Funding for R&D in CE related themes (e.g. direct or competitive grants) • Pre-commercial /R&D procurement for products and services with sustainable design • Providing R&D infrastructure • Innovation vouchers schemes for SME on CE related innovations • Support to innovation incubators focusing on CE related areas • Support programmes and incentives for R&D personnel
Information, capacity building and networking support	• Advisory services & information provision (to companies, start-ups, customers, technology adopters, etc.) • Professional training and qualification and skills enhancement courses, i.e. in material chain management • Support networking via matchmaking, technology platforms
Voluntary measures	• Performance label for products and services • Guarantee for product durability, repair, • Negotiated agreements (public-private sector) • Public or unilateral voluntary commitments (by private sector)

Source: Doranova and Gigli 2014.

4 TOWARDS THE CIRCULAR ECONOMY

The circular economy aims to boost the EU's competitiveness by protecting businesses against scarcity of resources and volatile prices by helping to create new business opportunities and innovative more efficient ways of producing and consuming (European Commission 2015, p.2). Policy frameworks like the European Commission's Circular Economy Action Plan or similar national initiatives aim to initiate eco-innovations that would enable fulfilling these ambitious objectives. For the circular economy to go from an attractive concept towards business reality, pioneers along the whole value chain are challenged to develop alternatives to the traditional "make-use-dispose" approach.

Already today new technologies, design concepts, services, and innovative forms of co-operation are contributing to the circular economy across the EU.

4.1 The "hardware" perspective

Becoming a circular economy will require radical eco-innovations that enable completely transforming the linear patterns of production and consumption that developed over the last two centuries and became an obviously wasteful but stable regime of over-consuming natural resources. The circular economy will thus require eco-innovations in two very different fields that could be labelled as circular economy "hardware" and "software": The technologies and technical infrastructures that would allow to turn waste (like glass, see the following good practice example) into resources (hardware) and at the same time the skills, expertise and business models that would turn this transformation into a business case (software).

The broad field of waste, waste collection and waste management forms a great part of the circular economy approach. With regard to the rising publicity of the concept of a circular economy as analogous to highly efficient waste treatment one might expect an increase of patents in the waste sector as an indication of technological innovation. However, a study conducted by Francesco Nicolli in 2013 suggests otherwise. This study took into account 28 countries (including e.g. UK, US,

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Germany, Japan, New Zealand, Mexico) and all patents in the waste sector filed under the Patent Cooperation Treaty (PCT) for over 25 years. These numbers were then compared to the total patent applications. It shows, that unlike the total patent applications, the number of patent applications in the field of waste is stagnating and at times (e.g. 1997, 2002 and 2005) even decreased. If divided into five categories (waste management, material recycling, solid waste collection, incineration and recovery, fertilizers from waste) in order to gain better insights into this trend, the two most the most dynamic categories for a circular economy with the most patent applications (waste management and material recycling) follow this stagnating and at times decreasing trend.

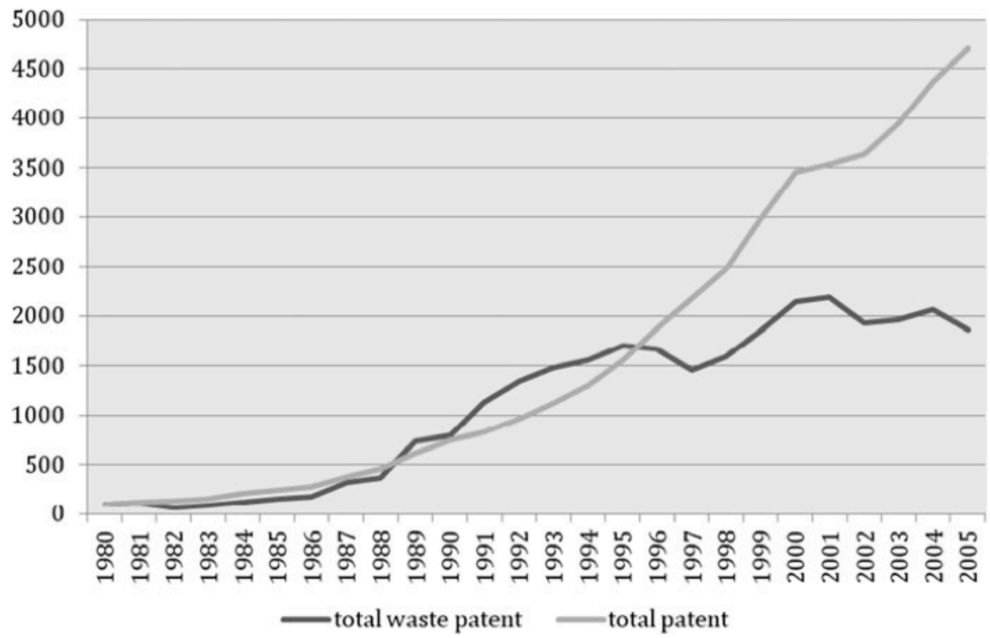

Figure 9: Number of patent applications filed under the PTC (total patent and waste patent, 3-year) (Nicolli 2013, p. 189)

Delving further into the question of why the numbers of waste patents are stagnating brings further insight. In many countries environmental problems associated with the existence and treatment of waste have been substantially reduced, and “security of disposal” has been broadly established as the objective of the waste management. Waste is in principle comprehensively collected and could be returned to the materials cycles. In fact, many actors now regard waste as a problem that has been “technically solved” (Wilts, von Gries, and Bahn- Walkowiak 2016)—although of course new challenges emerge from new products like for example wind turbines.

4.2 Sectors: Changing value chains and material flows

Circular economy eco-innovations in the European Union are clearly linked to challenges in specific sectors and value chain that are often characterised by particular resource intensity. Within its Circular Economy Action Plan the European Commission identified so-called priority waste streams as starting points for targeted measures that address the various phases of the cycle along the whole value chain. There are already viable eco-innovation activities in these different fields that highlight the innovation potential of the circular economy framework. In addition, however, the raw materials sector and especially critical raw materials also play an enormously important role in the context of new and eco-innovative technologies.

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4.2.1 *The Raw Materials Sector and its specific trends in technology and business fields*

An increasing number of raw materials can be classified as "critical" because they are both of high economic importance for the EU and vulnerable to supply disruption. The European Commission has published a list of such critical raw materials that includes, for example, rare earth elements and other precious metals, but also phosphorus.

The following sections are excerpted from a separate CICERONE paper on "The Raw Materials Sector and its specific trends in technology and business fields".[4]

Technology trends and expected raw materials demand

For high-wage industrial nations, competitive advantages on the global market are mainly from technical innovations. Taking Germany as an example, as one of the industrial countries, German industry is highly dependent on metal imports. In general, material costs account for around 40%, the largest share in the cost structure, for the German manufacturing industry (see Table 5). Hence, in order to remain its international competitiveness, securing raw materials supply is a rather important task. Since knowing the possible demand development is necessary for better estimation of long-term price and supply risks, especially when the emerging technologies are resource-intensive or -sensitive[5], DERA from Germany published a report in 2016 (revision from 2009) on emerging technologies and the forecasted raw materials demands. All information in this section was referenced from the DERA report.

Table 5: Cost structure of German's manufacturing industry in 2013 (excluding mining)

Type of cost	Share in %
Material costs	43.4
Energy costs	2.1
Personnel costs, wage labour and skilled trade services	21.9
Other costs (use of commodities, taxes, depreciation, etc.)	32.6
Gross production value without turnover tax	**100.0**

Source : Marscheider-Weidemann et al., 2016

The emerging technologies are defined as the technologies for which above-average growth in demand is expected in the future. They can be individual technology (e.g. fuel cells and RFID labels) or systematic innovations which combine existing individual technologies into new applications (e.g. automatic piloting of vehicles). They hold industrially exploitable technical capabilities triggering revolutionary innovations far beyond the boundaries of individual sectors and profoundly change economic structures, social life and the environment in the long-term.

The report identified in total 42 emerging technologies from various industrial sectors (see Figure 10) and their resource demands up to the year 2035 are estimated. The year 2035 was chosen considering mine construction could take up to ten years or more. However, it should be noted that future trends outside of these projections are plausible, for example, emerging technologies could also reduce demand for metallic raw materials.

[4] For more specific and comprehensive information and data on critical resources, please refer to CICERONE full paper «Overview of Raw Materials Sector in Circular Economy and Trends in Technology and Business Fields », by Meng Chun Lee & Wolfgang Reimer (GKZ), 2019, which is available in full length as WP5 paper. In consultation with the authors, some excerpts were used here for illustration purposes.

[5] Resource intensive: If a technology is expected to trigger an increase in demand of more than 25% of current (2016) global production of a raw material in at least one bulk metal; Resource sensitive: If a technology brings an increase in demand of more than 100% of current (2016) global production of this raw material in at least one specialty metal (i.e. resources with a worldwide production of up to thousand tons per year).

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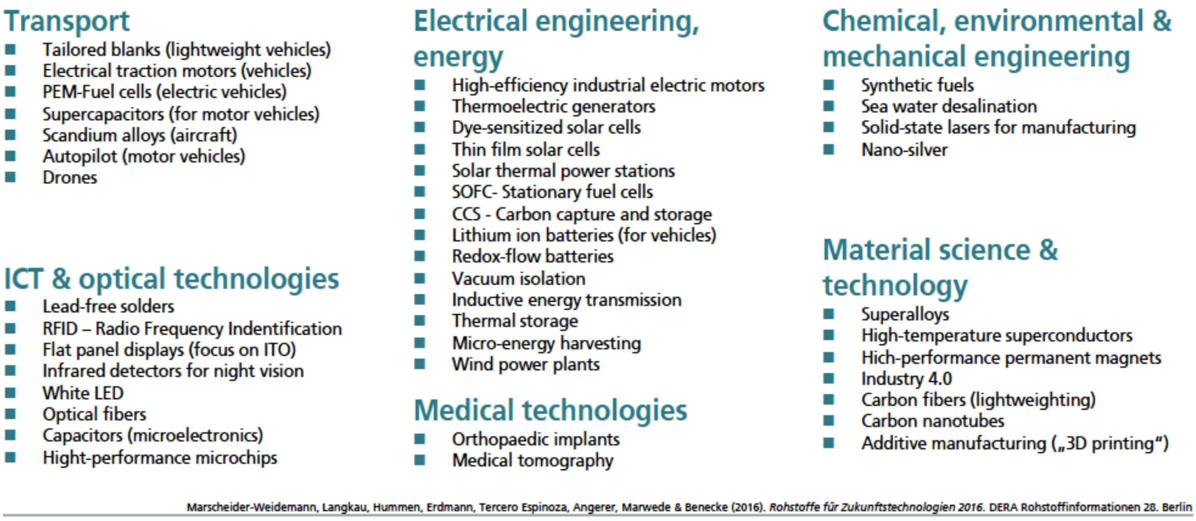

Figure 10: Identified emerging technologies sorted by industrial sectors (Marscheider-Weidemann et al., 2016)

Based on the research result of DERA, the sole demands in 2035 from the emerging technologies could equal or exceed the primary production in 2013 for five metals (i.e. germanium, cobalt, scandium, tantalum, and neodymium/praseodymium). Furthermore, the demands of three metals could be doubled comparing to the primary production 2013 (i.e. lithium, dysprosium/ terbium, and rhenium). More detailed information regarding the expected RM demand of emerging technologies is shown in Figure 11 and Table 6. The report also assessed the recycle potential of the emerging technologies, many of which are regarded as limited (i.e. economically feasible to some extent) or no (i.e. not economically feasible).

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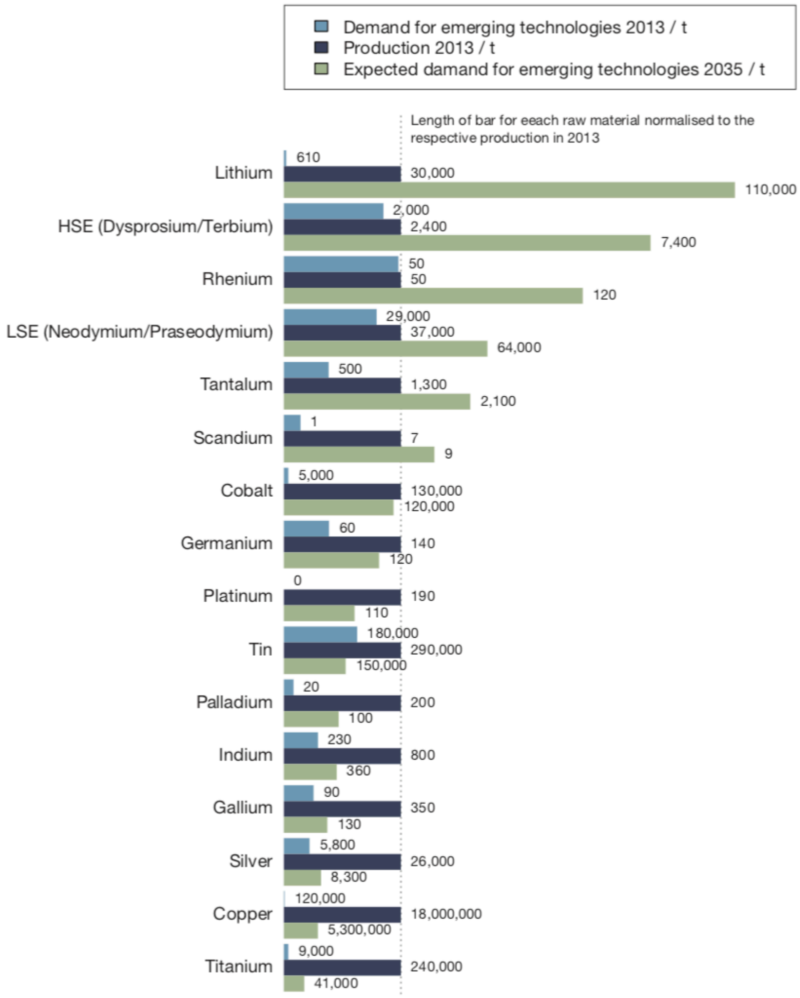

Figure 11: Estimated demands of the selected raw materials for emerging technologies in 2035 compared to the respective primary production level in 2013 (Marscheider-Weidemann et al., 2016)

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Table 6: Global demand for metals for the 42 emerging technologies in 2013 and 2035 compared to the global production volume of the respective metals in 2013*

Metal	$Demand_{20xx}/Production_{2013}$		Emerging technologies
	2013	2035	
Lithium	0.0	3.9	Lithiumion batteries, lightweight airframes
Heavy rare earths (Dy/Tb)	0.9	3.1	Magnets, e-cars, wind power
Rhenium	1.0	2.5	Super alloys
Light rare earths (Nd/Pr)	0.8	1.7	Magnets, e-cars, wind power
Tantalum	0.4	1.6	Microcapacitors, medical technology
Scandium	0.2	1.4	SOFC fuel cells
Cobalt	0.0	0.9	Lithium-ion batteries, XtL.
Germanium	0.4	0.8	Fiber optic, IR technology
Platinum	0.0	0.6	Catalysts, seawater desalination
Tin	0.6	0.5	Transparent electrodes, solders
Palladium	0.1	0.5	Catalysts, seawater desalination
Indium	0.3	0.5	Displays, thin layer photovoltaics
Gallium	0.3	0.4	Thin layer photovoltaics, IC, WLED
Silver	0.2	0.3	RFID
Copper	0.1	0.3	Electric motors, RFID
Titanium	0.0	0.2	Seawater desalination, implants

Note: the results in this table are not comparable with the previous study because they are based on a different period (22 instead of 24 years), a different reference year (2013 instead of 2006), a different technology portfolio (42 instead of 32) and more recent findings concerning innovation dynamics.

Source : Marscheider-Weidemann et al., 2016

*Note : This does not consider any raw material demand beyond these technologies.

Four emerging technologies are selected from the 42 emerging technologies and introduced in more details in the GKZ report (Figure 10) due to their substantial impacts on critical raw materials supply in terms of criticality of elements and forecasted demand in the long term. They illustrate the importance of identifying technology trends that are associated to excessive corresponding RMs demands in time and consumer as well as manufacturing markets.

Recycling rates of metals and EU CRMs

The following Figure 12 presents recent figures on the EoL recycling input rates of the EU CRMs. The EoL recycling input rate refers to how much of the total material input into the production system comes from recycling of 'old scrap' (i.e. post-consumer scrap).

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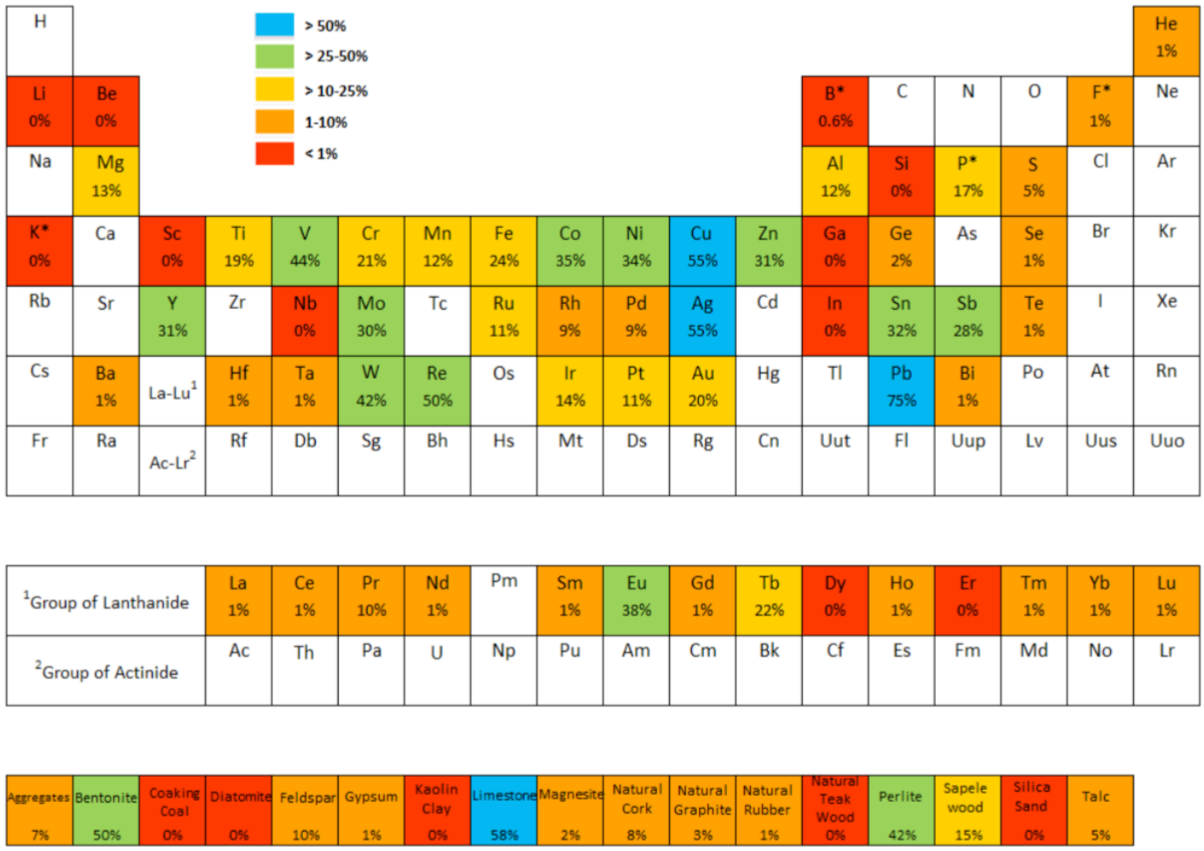

* F = Fluorspar; P = Phosphate rock; K = Potash, Si = Silicon metal, B=Borates.

Figure 12: EoL recycling input rates of the EU CRMs (JRC, 2017)

However, it should be noted that the generally low recycling input rates could be explained by several factors including the lack of economically viable sorting and recycling technologies for CRMs, the technical limitations (e.g. incapable to recover in-use dissipated materials), the long-life time of many CRMs applications, and the growing demands of many CRMs (i.e. the recycling contribution is insufficient to meet the demands, e.g. PGMs have recycling rate up to 95% for industrial catalysts and 50 to 60% of automotive catalysts but the recycling input rate is only 14%.) (Mathieux et al., 2017).

Factors affecting accessibility of critical raw materials for CE

The sections above provided an overview of the estimated future demands of raw materials due to emerging technologies and the EU CRM recycling input rates. Both imply that the further development in the secondary raw materials sector is a must and will encourage further R&D and support actions to improve the exploitation of the results. The development of the secondary raw materials sector, including R&D activities and exploitation, is nonetheless affected by many factors. In this section selected factors (i.e. identified) are introduced. The first part presents factors appearing in the raw materials market the second part showcases technical factors (i.e. metallurgy).

In the global raw materials market, four factors which can especially affect the development of secondary raw materials sector are identified:

- Accessibility to primary raw materials,

The easy access to primary raw materials limits the development of secondary raw materials markets and substitution materials markets. In contrast, limited access to primary raw materials by political

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restrictions, transport or societal resistance stimulates the development of secondary raw materials and substitution materials markets. Two examples are provided to illustrate the factor.

Example 1: Low development of secondary raw materials sector due to easy access to raw materials (international competition) – low recovery rate of lithium

Example 2: Low development of secondary raw materials sector due to easy access to raw materials (other natural forces, e.g. climate change) – newly accessible artic deposits in Greenland and Russia

- Relevant policies, regulations and political objectives

The impacts of policies and legislations on market-oriented economies are unavoidable. They may support market economies, initiating new business, or hinder market economies. The secondary raw materials sector is also affected by relevant policies, regulations and political objectives. Depending on the political decision, it could be beneficial to the R&D activities in raw materials sector but could also be detrimental. Few examples are illustrated below.

Example 1: EU policy as the driver – Electric vehicle target of the EU

Example 2: Foreign policy as the driver – China's import ban on plastic wastes

Example 3: EU policy as the barrier – Debate on the ban of lead in the EU

- Political interferences in markets

Example: China's policy on its rare earth elements market

Due to limits of the current technologies, there are raw materials that cannot be recovered from secondary sources but have visible primary raw materials supply risks. In this case, other measures (e.g. substitution) other than developing secondary sources are recommended for securing raw materials supply.

For more specific and comprehensive information and data on critical resources, please refer to CICERONE paper **Overview of Raw Materials Sector in Circular Economy and Trends in Technology and Business Fields, by Meng Chun Lee & Wolfgang Reimer (GKZ), 2019**, which is available in full length as WP5 paper. In consultation with the authors, some excerpts were used here for illustration purposes.

Recovery rates

The following Figure 13 illustrates the specific challenge of so far disappointingly low recovery rates and missed economic opportunities. The European Commission states that increasing the recovery of critical raw materials is one of the challenges that must be addressed in the move to a circular economy.

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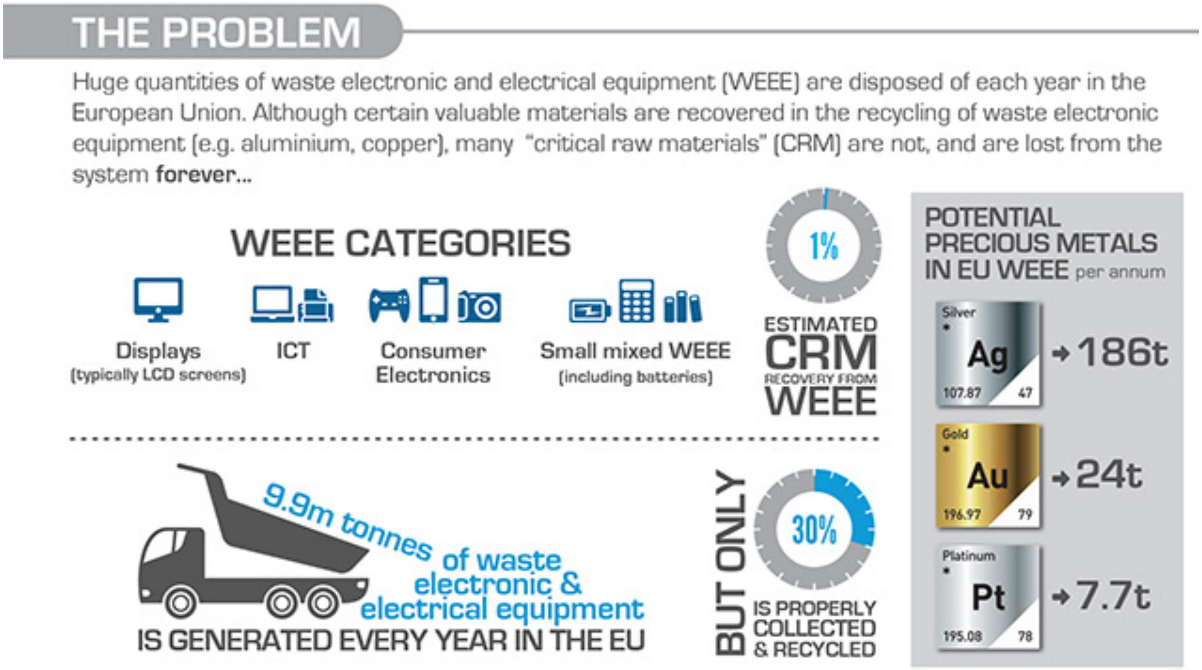

Figure 13: Recovery rates and material leakages (CRM 2014)

Key barriers include insufficient information exchange between manufacturers and recyclers of electronic products, the absence of recycling standards, and a lack of data for economic operators on the potential for recycled critical raw materials. Against this background, technical and organisational eco-innovations will have to play a crucial role in order to secure the supply of critical raw materials—that are to relevant amounts used for green technologies like fuel cells or photovoltaic panels. Projects like ReVolv aim to develop product-specific technologies that would allow in this case indium from LCD displays.

4.2.2 Plastics

The CE Action Plan has clearly stated that especially increasing plastic recycling will be essential for the transition to a circular economy. The use of plastics has grown steadily. The global production increased from 1.7 million tons in 1950 to 288 million tons in 2012 of which around 20% were produced in Europe. This has led to a generation of plastic waste of about 25 million tons; less than 25% of collected plastic waste is recycled and about 50% goes to landfill or even worse ends up in the oceans as marine litter (Plastics Europe 2013). The presence of hazardous chemical additives can pose technical difficulties and the emergence of innovative types of plastics raises new questions, e.g. as regards plastics biodegradability.

However, our current consumption patterns would not be imaginable without the use of plastics. The innovation in plastics can contribute to lowering environmental impacts and developing the circular economy by better preserving food, improving the recyclability of plastics or reducing the weight of materials used in vehicles—leading to significantly reduced fuel consumption and CO_2 emissions. On-going eco-innovations in this field also include more integrated packaging concepts that aim to minimise the use of unnecessary plastics or plastics of environmental concern and in this way support the prevention of plastics waste. Concepts like the Holis market in Austria also offer consumers the possibility to purchase only the exact amount of food that they want instead of being limited to specific packaging sizes.

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4.2.3 Bio-based products

Bio-based products made out of renewable biological resources (such as wood, crops or fibres) will have to play a crucial role in a circular economy. Bio-based materials can present advantages linked to their renewability and biodegradability; such elements of a bio-economy provide alternatives to fossil-based products and energy, e.g. in the fields of construction, furniture, paper, food, textile, chemicals as well as energy uses like biofuels (European Commission 2015). The drive to shift the material composition of consumables from technical towards biological nutrients and to have those cascade through different applications before extracting valuable feedstock and finally re-introducing their nutrients into the biosphere, rounds out the core principles of a restorative circular economy (Ellen MacArthur Foundation 2014, p. 23).

At the same time, the objective of replacing non-renewable with renewable resources may increase competition for land in a circular economy and thereby increase pressures on natural capital. Bio-based materials compete with production of both food and biomass for energy generation, as well as with land use for other purposes (including e.g. conservation of biodiversity). In general, biomass is best used in a cascade in which energy generation is the last step rather than the first. But even if biomass is primarily used for durable products, environmental impacts are not straightforward. A key example is wood as a construction material. The benefits of this renewable resource should be offset against the biodiversity impacts of increased wood harvest, with current harvesting rates in Europe already reaching 65 % of the annual increment and imports on the rise in many European countries, in particular to meet renewable energy targets. Analogous to the debate on bio-energy, the potential for uptake of bio-based materials should be critically analysed in view of overall biomass production and ecosystem resilience (EEA 2015).

Nevertheless, the European Commission has highlighted that eco-innovations in the bio-based sector have already shown their potential for innovation in new materials, chemicals and processes, which can be an integral part of the circular economy. Researchers are working to develop novel applications and processes that could potentially generate a higher added value than existing uses, such as biorefining, insect breeding, the production of C_5 and C_6 sugars, solid state fermentation, and more efficient biogas production processes (Bastein et al. 2013). The Bio Base Europe Pilot Plant is an excellent example for infrastructures to test these innovations for market readiness and to upscale their implementation and contributions to a circular economy.

4.2.4 Food waste

The European Commission has identified food waste as an increasing concern in Europe. Across the globe, nearly 30% of food is wasted throughout the agrifood supply chain. Around 100 million tons of food is wasted annually in the EU (estimate for 2012). Modelling suggests— if nothing is done—food waste could rise to over 120 million tons by 2020. The food resources being lost and wasted in Europe would be enough to feed all the hungry people in the world two times over. In September 2015, as part of the 2030 Sustainable Development Goals, the United Nations General Assembly adopted a target of halving per capita food waste at the retail and consumer level, and reducing food losses along production and supply chains. The EU and its Member States are committed to meeting this target.

Together with shifting to more sustainable diets, reducing food waste both in and out of the home is the most significant demand-side measure for reducing the carbon impact of the food system. But also supply-side eco-innovations will be able to contribute to the prevention of food becoming waste: It will require to design and develop technological innovations to improve valorisation of food

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waste, e.g. from food processing, and ICT-based platforms and tools to support new and existing solutions to reduce food waste[6]. The ResQ Club in Finland can be considered as one of the most promising eco-innovations in this specific area of a circular economy.

4.2.5 Construction and demolition

The most relevant waste stream stems from construction and demolition activities: It accounts for approximately 25% - 30% of all waste generated in the EU and consists of numerous materials, including concrete, bricks, gypsum, wood, glass, metals, plastic, solvents, asbestos and excavated soil. Many of the materials are recyclable or can be reused, but reuse and recycling rates vary widely across the EU.

The recycling of construction and demolition waste is encouraged by a EU-wide mandatory target, but challenges on the ground still have to be addressed if waste management in this sector is to improve. For example, valuable materials are not always identified, collected separately, or adequately recovered. Given the long lifetime of buildings, it is essential to encourage design improvements that will reduce their environmental impacts and increase the durability and recyclability of their components. The GOMOS system (i.e. a modular system of reinforced concrete developed in Portugal for tiny houses) is an excellent example for necessary eco-innovations that bridge the design phase with the end-of-life phase of buildings.

4.3 The “software” perspective

Completely different kinds of eco-innovations can be found on what could be described as the software of the circular economy: Innovative forms of business models and consumption patterns that enable maintaining the value of products and raw materials as long as possible.

Not all business models in a circular economy need to be highly innovative or be completely new compared to the business models in place today, but some business models will be. Ideally they will all support the circular economy and form a part of it—either because the business model itself is completely focussed on the circular economy or because it is at least partly using the provided infrastructures, products or services enabling the circular economy.

Some businesses’ business models will focus on providing these infrastructures, products and services. Other businesses will use them either to build their business model based on this provision or they will make use of it in order to round out their business model or to fulfil legal or other requirements. As such most of the following concepts can be seen as either the core part of business models providing the infrastructure or as a part of other businesses’ business model.

The basic infrastructures to a circular economy are collection systems or platforms linking the demand and supply side in order to enable waste-as-a-resource procedures or the distribution and use of secondary raw materials. These systems will most likely benefit from a cross- border, cross-industry and cross-sector reach and from global supply chains, which will form a major part of reverse cycle networks and the distribution of (used) products, components and materials (Ellen MacArthur Foundation 2014). Businesses are needed which offer the facilities or services to treat products and materials in order to reuse, repair, remanufacture or recycle them. Many businesses will incorporate this waste-as-a-resource, either directly through using bought or self-produced waste, by-products or end-of-life products or components or indirectly through selling them.

[6] http://eu-refresh.org/about-refresh#background

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But sometimes it might not be so easy to determine whether reusing, repairing, remanufacturing, recycling or selling would be the right treatment for a product, component or material. The businesses in a circular economy will therefore need support in this decision-making process, for example through tools that take into account various factors like for example the product's condition, the market situation, environmental effects and economic factors and so on. The provision of such tools could be another business model (Ellen MacArthur Foundation 2016). Strongly linked to the ability of making these decisions is the idea of eco-design. Already in the design stage of developing new materials, components or products, businesses in a circular economy need to think about the after-use-span and how the product can be treated and ideally enter another cascade step or life-cycle. Eco-design has to deal with the question of how the design enables easy reuse, repair, recycling etc., how disassembling (manually, technically, chemically, biologically etc.) without any losses in terms of quality or quantity can be facilitated and what materials should be used (e.g. composition, hazardous material content, pure material content). Through these considerations the durability should be enhanced, so that the materials, components or products can either enter more cascade steps or life-cycles or spend more time within one cycle. The benefits of eco- design would be energy and material savings and the chance to design out waste (EEA 2015, Ellen MacArthur Foundation 2013).

Today, most business models, regarding the provision of products, are based on selling items and generating one-time earnings. The enhanced durability of products might therefore seem contra productive—but service- and function-based business models (where product-as-a- service forms one part often referred to) will benefit from this[7]. Leasing, renting, sharing, and pooling and the so called collaborative consumption, performance contracts, predictive maintenance, and remanufacturing will form typical parts of the new service- and function- based business models (EEA 2016a, p. 15). As the earnings generated within these business models are rather performance-based and are reoccurring, instead of one-time earnings, the financial structure of such businesses will change compared to the financial structure of businesses with traditional concepts. As large scale payments at the start of the products' life- cycle are not generated, but reoccurring payments, these business models might even require new financial models (EEA 2016).

Some new business models will again deal with the provision of the necessary infrastructure like market places in order to match the offers and the demand side, some businesses will incorporate the services related to for example leasing, others will offer to provide these services for other businesses and within the organisation, and some will focus on the provision of completing services like insurances, which will be especially interesting for business models focussing on product-as-a-service options or sharing.

Generally, more connections between players of the economy will exist in a circular economy, either directly between for example businesses or indirectly through infrastructure and/or global supply chains. Another option could be through some kind of market space, which aims to match existing offers and demand in terms of products, components, materials and services in order to enable cascade usage, and longer or more cycles. And more business models than today will rely on the Internet of Things or Industry 4.0, as it will help to run business models containing for example product-as-a-service offerings, which require (real-time) information about the usage of a product or

[7] Of course, enhancing the durability of materials and leading them into cascaded usage, reusing them or recycling them is also a crucial benefit.

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component as well as its condition[8]. Feedback from products could also be used for product enhancements (Ellen MacArthur Foundation 2016).

But also eco-innovations in the field of consumption will be necessary to support the development of the circular economy, e.g. sharing products or infrastructures (collaborative economy), consuming services rather than products, or using IT or digital platforms (Fischer et al. 2015; Leismann et al. 2013). And especially such “Industry 4.0” approaches or web-based applications could become powerful enablers of a circular economy, especially in the field of collaborative consumption based on sharing, swapping, bartering, trading or leasing products and other assets such as land or time (Botsman and Rogers 2010). While such peer-to-peer interactions have long been practised on a local scale, they have developed into a different dimension through the use of online sharing marketplaces, through which the demand for certain assets, products or services is matched with their supply, usually through consumer-to- consumer (C2C) channels. A key challenge will be to set the right policy and incentives frameworks that ensures that the transition from consumers to “prosumers” actually boosts eco-innovations and does not simply lead to rebounds regarding traditional or even more resource intensive consumption patterns, e.g. spending vacation money saved by AirBnB for buying more long-distance flights.

Conclusively, Table 7 maps the application of circular economy processes in different sectors.

Table 7: Mapping of application of circular economy in different sectors

Objectives	Circular process	Examples of sectors where circular processes can be applied
Use of less primary resources	Recycling	Automobile industry, Textile industry, Building sector, Packaging sector, Critical Raw materials, Forest sector, Chemical industry
	Efficient use of resources	Building sector, Plastics industry, Mining and metals industry, Food sector
	Utilisation of renewable energy sources	Chemical industry, Food industry, Forest sector
Maintain the highest value of materials and products	Remanufacturing, refurbishment, reuse of products and components	Automobile industry, Manufacture of computer, electronic and optical products, Building sector, Furniture sector, Transport
	Product life time extension	Manufacture of computer, electronic and optical products, Automobile industry, Household appliances, Building sector, Food industry, Textile industry, Defence industry
Change utilisation patterns	Product as service	Household appliances, Transport, Building sector, Printing industry
	Sharing models	Automobile industry, Transport, Accommodation, Clothing
	Shift in consumption patterns	Food sector, Publishing sector, E-commerce sector

Source: (Rizos, Tuokko, & Behrens, 2017) p. 17

[8] Example could be Philips – Lighting as a service.

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5 Conclusions

The following draws conclusions with regard to the role of innovation and R&D as well as related policies for transformations towards a circular economy.

Circular economy is increasingly represented in the strategic national policy agendas of the EU Member States

Evidence of the benefits of a transition towards a circular economy has increased over recent years. This has led to the increased embracement of the circular economy concept in society. Circular economy is currently penetrating the strategic national policy agendas of the EU Member States. A few countries address circular economy in the more generic context of their resource efficiency strategies, where it is addressed in a somewhat narrow definition based on material efficiency, recycling and waste prevention or management. However, there are examples of more ambitious and more comprehensive strategies, such as the recent circular economy strategy of Scotland that has a more systemic approach tackling the products design, durability, reuse, reparability, etc. as well as promoting new business models that can be at the core of the circular economy.

Promising eco-innovations can be found across the EU but there are gaps between good intentions and changed behaviours

Promising eco-innovations can be seen across the EU with the potential to be scaled-up. This includes in particular eco-innovations at the design phase. However, most efforts seem to be concentrated in individual markets or market niches instead of bridging the full circular model from design to disposal. Citizens seem willing to embrace environmental products through their purchasing decisions, but confusion exists as regards what is "green" and there seems to be a gap between good intentions and changed behaviours. Bottom-up approaches such as repair, reuse and sharing initiatives set powerful examples of how change may be implemented, but seem to remain in certain social niches instead of penetrating the mainstream.

Lack of knowledge and uncertainty in the transformation from waste to a circular resource management is apparent

Despite the increased presence of the circular economy in the policy discourse, the majority of activities at the Member States level is still overwhelmingly regarded as waste management measures, which indicates a lack of knowledge and general uncertainty in the transformation from waste to a circular resource management. Existing regulatory framework conditions are not favourable for engaging in circular economy activities. On the one hand, there is a need to break the “lock-in” in existing systems for waste management. On the other hand, there is a need to move towards alternative systems for consumption (e.g. sharing, reuse) and production (e.g. repair, remanufacturing). Product design is an important element in shifting to these alternative systems, therefore creating framework conditions for promoting the alternative design of products should be one of the main emphases of the circular economy policies.

Barriers to the transition towards a circular economy have to be overcome

There are also a number of barriers to the transition towards a circular economy, including the falling commodity prices since mid 2014, insufficient investment, lack of skills and know-how, limited acceptance of alternative models of consumption and business, and lack of policy coherence. In

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shifting to circular economy, there should be a systemic approach that addresses many barriers in a comprehensive way and creates favourable framework conditions (e.g. embracing regulation, institutional settings, targets, instruments, curricula, infrastructures, networks, key actors, etc.). Policies will play a key role in this.

Eco-innovation = Hardware and software solutions

Eco-innovation is an important element of all circular economy efforts. Different types of eco-innovations, i.e. product, process, organisational, marketing, social, system eco- innovation, are instrumental in transforming a linear economy into a circular economy. Building a circular economy will require boosting and creating favourable conditions for all types of eco-innovation.

The circular economy will require eco-innovations in two different fields that could be labelled as the circular economy “hardware” and “software”: first being technologies and technical infrastructures and second being skills, expertise and business models that would turn this transformation into a business case.

- The patents statistics shows that whilst the growth rate of overall technological inventions is constantly growing, inventions focused on waste management and recycling has not been developing to the same extent over the last decade. This was due to limited focus on waste disposal, which has been seen as a “technically solved” problem. There is a strong need to promote R&D addressing wider concepts of circular economy, including circular design of products (e.g. durable, repairable, remanufacturable, etc.), as well as recycling, urban mining, and valorisation of waste as resources.
- The “Software” of circular economy is another highly important element that needs a strong support and framework conditions in order to develop. Business models based on the new consumption patterns and offering functionalities of products rather than the products themselves will need to gain bigger diffusion.

Creating favourable conditions for both the “hardware” and the “software” for the circular economy should become a part of a holistic policy support strategy. While supporting the “hardware” is something where policy makers can rely on the traditional innovation support instruments, development of “software” requires innovative approaches in policymaking. Much of the efforts should be focused on changing the mind-sets of consumers and creating an environment where companies can find economic prospects in business models based on sharing, remanufacturing, reuse and repair.

Stakeholders, policies and different responsibilities

For different stakeholders, circular economy will have different meanings and involve different roles and responsibilities. For each of them, framework conditions should provide direct or indirect incentives to act, plan, consume, produce or engage in business in a manner that contributes to circular economy.

To promote initiatives of circular eco-innovations the national and local governments can deploy a range of policy measures. These can be regulatory instruments, economic instruments, such as fiscal and financial incentives (taxes, fees), direct funding, demand pull instruments (e.g. procurement), R&D support measures, such as grants, infrastructure provision, supporting R&D personnel, information, education and networking support measures, and voluntary measures including performance labels and guarantees for products, voluntary agreements and commitments. Application of these measures in the context of circular economy development in Member States is

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not yet very wide. However, there is an opportunity to learn from selected policy initiatives and new practices on national and municipal levels that have been emerging.

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