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Eco-innovation and Competitiveness

Enabling the transition

to a resource-efficient circular economy

Annual Report 2013

July 2014

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Eco-Innovation

Enabling the transition to a resource-efficient circular economy

Annual Report 2013

July 2014

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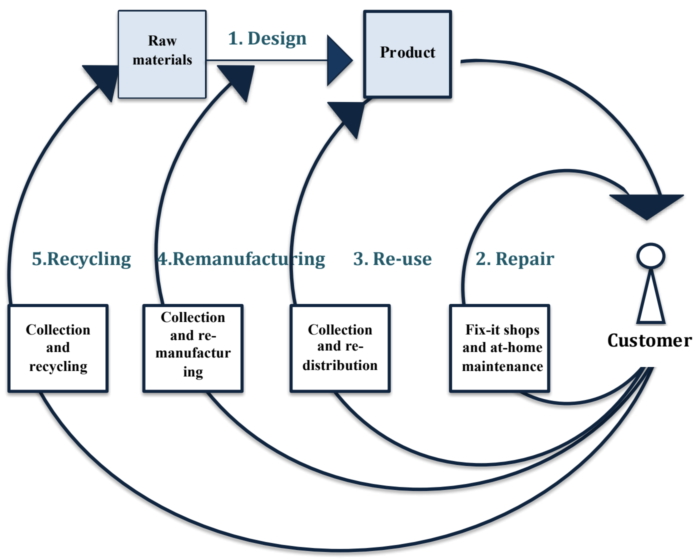
Executive summary

Eco-Innovation will fuel the transition to a circular economy. This report presents evidence of changes already happening across the EU and highlights some of the key barriers and future challenges toward mainstreaming a circular economic model**. It argues that the circular economy concept offers a model of resource flows through the economy that may underpin the vision of a resource-efficient Europe. Eco-innovation will enable the transition by changing dominant business models, transforming the way citizens interact with products and services, and developing improved systems for delivering value**. This report looks at five activities that are crucial to building up resource-efficient material flows across the EU: design, repair, reuse, remanufacturing and recycling.

Figure 1. Circular economy: depicting the flows assessed in this report



Eco-design aims to offer new solutions that are profitable, attractive and which lead to an overall reduction in the consumption of materials and energy. It builds the foundation for products catered to a circular economy model and strongly links to the development of product-service system based business models, dematerialisation based innovative solutions, and frugal innovation**. Changes in design will be most effective if associated with system adaptations, such as changes in infrastructures synced with re-usable products or product components, improved skills, and social acceptance. This type of system eco-innovation is both one of the largest opportunities and challenges for eco-design**. The EU Ecodesign Directive has made considerable inroads toward improving the energy efficiency of products during their use phase, but provides insufficient incentives for a comprehensive life-cycle approach from a resource efficiency perspective. Risks associated both with breaking out of perceived niche markets and novel design approaches coupled with redefined business models (e.g. modularity) hinder eco-innovation activities in companies. Key challenges relate to linking product design with business models that promote circularity.

Repair and maintenance play a key role in both service based eco-innovative business models (based on sharing, rental, product-service systems) and social eco-innovations, which promote changes in behavior and consumption traditions. **Business models offering life-time product guarantees or repair integrated in after-sales services, as well as companies specialised in maintenance services (of e.g. cars, appliances, and machines), are well established in the current economic system and could play a stronger role in the future.** Recent trends reveal the emergence of decentralised, grassroots approaches to making and fixing products (e.g. tech shops, fab labs, repair cafés) as well as a growth in social enterprises that merge social and environmental objectives and provide opportunities for increasing employment.

Special Feature: The EU and Global Eco-Innovation Scoreboard

The Eco-Innovation Scoreboard is a tool to assess and illustrate eco-innovation performance across countries. This report presents the 4th edition of the European Eco-Innovation Scoreboard and, for the first time, presents a Global Eco-Innovation Scoreboard. At a European level, Sweden, Finland and Germany ranked highest in the composite score (16 indicators arranged in 5 components) in particular due to their top performance in the components of eco-innovation inputs, eco-innovation activities and eco-innovation outputs. The Global Eco-Innovation Scoreboard covers 127 countries with 14 indicators in total. It revealed that European countries perform very well when analysed in a global context. The top 15 performers are all located within Europe, followed by the USA, South Korea and many of the OECD countries.

The scoreboard, indicators and data are available on the EIO website: www.eco-innovation.eu/

Such bottom-up movements have, so far, generally developed without policy support. On the contrary, **policies providing incentives to recycle may have an adverse impact on the opportunities for repair of certain products**. Instruments such as reduced VAT taxes on repair work could boost viability of the industry. This is particularly relevant in light of the widespread availability of cheap products, often making repair the more costly and time-consuming choice. Increasing product complexity as well as the trend toward integrated components requiring special tools for repair also makes fixing broken products a challenge for citizens, and links to the need for products designed with repair options in mind.

Re-use relates to aspects like longevity, durability, and reparability, and thus closely links to product design and business models that embrace a long-term perspective. **The current focus of re-use activities is on products from private households like clothing, furniture and electronics and the trend toward re-use is strongly associated with internet platforms and online exchange services (like e-bay) as well as charitable activities.** According to a 2011 Eurobarometer survey young people, well-educated people, and citizens of highly developed EU12 countries were most likely to report a willingness to engage in re-use. The most common reasons for not buying second-hand products were related to product quality. This raises questions as to whether the higher levels of reported citizen engagement in re-use in highly developed countries like Sweden, Finland and Denmark is related to a higher turnover of high-quality products in those countries or whether it is indicative of a 'mind-shift' toward more environmental-friendly behaviour. In some cases, risks of a rebound may counter environmental benefits. For example, if the availability of cheaper second-hand goods leads to an increase in consumption. This implies that **for re-use to scale up to a societal transition it must be accompanied by a change in citizen behaviour.** There is a major opportunity for user-led eco-innovations in the private sector and in business-to-business relations to expand the re-use practice to new products and materials.

Re-manufacturing has been called a "hidden giant" because it operates at a relatively low level of visibility, but has significant potential for boosting both economic growth and job creation while saving materials. It has been particularly prominent in the US, where it is estimated that the price of a remanufactured product is normally between 45% and 65% of the price of a comparable new product. Lead markets in in the UK and, to a lesser extent, Germany are emerging in the EU. So far, the bulk of remanufacturing activities has been concentrated on products like ink and toner cartridges, pumps and compressors and products within the automotive sector. **A coherent, EU policy approach to remanufacturing in relation to re-use or recycling is missing**. There is a risk that supply chain operations may be pushed towards recycling, even in cases where remanufacturing could make more economic sense. Remanufactured products are by nature meant for the long term and require changes in the way consumers interact with and purchase products. A challenge is finding a balance between closed loop products now and the innovations of the future, considering that remanufacturing may favour incremental improvements which should not lock-in the opportunities for more disruptive eco-innovation.

EIO Country Profiles

EIO country profiles have been updated for all 28 Member States. Each brief provides a short overview of eco-innovation performance, new trends, barriers and drivers, and the policy landscape specific to that country. Good practice examples provide an overview of activities on the ground. These briefs were drawn from in the preparation of this report. They are available for download on the EIO website: www.eco-innovation.eu.

Recycling is a well-established eco-industry and one of the priorities of resource efficiency policy in the EU. Significant improvements in recycling were achieved between 2001 and 2010, yet enormous gaps between the performance levels of Member States remain. In top performing countries many of the 'easy wins' in recycling have already been achieved; future challenges relate to shifting material recovery from downcycling to upcycling and increasing recycling in waste streams like biowaste and electronics. **The regulatory framework focuses on the volume of waste rather than on its potential material qualities as a secondary resource**. This is because waste has been traditionally viewed as an environmental burden and cost that should be dealt with locally. However, recycling often requires large amounts of a specific type of waste in order to be economically viable, making the scope of operations regional or even cross-national. Waste incineration plants increasingly compete with enhanced recycling efforts. One approach is the development of an integrated European recycling infrastructure and network that could allow recycling facilities, and as a last resort, incineration to respond to the actual needs.. Prior to any major investment decisions, however, both recycling and incineration needs should be assessed at the European level taking into account medium- to long-term trends.

This report has identified significant eco-innovation potential in the main activities underpinning a circular economy. Most eco-innovation activities seem to currently take place in market niches on the level of single products and companies, with recycling being the best established in the current economic system. A number of fundamental, cross-cutting challenges hinder the greater uptake and practical implementation of the circular economy model. Most challenges are of a systemic nature, including infrastructural lock-in, unfavourable regulatory frameworks, networks organised around vested interests, risk-averse organisational models or value systems underlying choices and practices of producers and consumers. The most difficult challenge for the transition to a circular economy, and the principal task of policy, will be to overcome systemic lock-ins.

Policy messages

- **The policy striving for a circular economy needs to be based on a systemic vision on how to reach a resource-efficient circular economy**. This implies an explicit reflection on the desired roles, dependencies and possible rebounds related to extraction, repair, re-use, remanufacturing and recycling.
- **A comprehensive review of the current policy mix and regulatory framework is needed**, in particular to identify potentially conflicting visions and measures in the current policy mix at the EU and national levels (e.g. recycling versus waste avoidance).
- **Policies supporting the shift to a circular and resource efficient economy need to embrace system innovation**. Changes on the level of individual companies are necessary but simply not enough to overcome systemic challenges and lock-ins.
- Given the scale and complexity of challenges, **innovation policy needs to combine efforts to provide a level playing field for all innovators with a deliberative, concentrated support to selected priority areas**. While not being prescriptive about 'how to get there', the framework conditions need to be clear about the objectives, targets and 'rules of the game' (e.g. criteria, standards, norms).
- **A policy portfolio that creates a protected innovation space for eco-innovators** (e.g. through dedicated funding opportunities) **is needed** to share risks of entrepreneurial discovery processes and to provide support to market formation relevant to the circular economy transition.

Introduction

The report rationale, research objectives and questions

The circular economy is emerging as a key strategy for the transition to a resource-efficient Europe. It is increasingly used in the discourse of policy makers, NGOs, and analysts, but little is known about what the circular economy means in practice. A recent survey of almost 300 SMEs in France, Belgium and England revealed that around half of the companies interviewed had never heard the term and a quarter were not sure what it meant[4] (Fusion 2014). This report aims to fill this gap by discussing the concept of circular economy in the context of eco-innovation.

Eco-Innovation will fuel the transition to a circular economy. The Eco-Innovation Observatory has been examining issues related to eco-innovation for four years. This report builds on past EIO Annual Reports and continues the narrative related to system eco-innovation, material flows, business models and the resource efficiency transition. It highlights opportunities for “slow and fast wins”, which merge economic, environmental and social aims over different time periods.

This report aims to introduce a conceptual basis for looking at how eco-innovation can contribute to the circular economy and how it relates to resource efficiency. **It presents evidence and good practice examples from across the EU and highlights policy challenges linked to achieving the vision as laid out in the Roadmap to a Resource Efficient Europe** (EC 2011a). The report provides answers to the questions:

- How do circular economy and resource efficiency relate?
- What is the role of eco-innovation in the transition to a resource-efficient circular economy?
- What type of eco-innovation is happening to promote circular economy across the EU?
- What are the key barriers and drivers of eco-innovation and the transition to a circular economy?
- What are the recent policy measures in EU Member States that support circular economy?
- What are the key challenges for (1) eco-innovators and (2) for the transition to a resource efficient and prosperous circular economy?

Overall vision on the scope of the report

This report discusses how eco-innovation can contribute to different aspects of the circular economy. It will introduce the concepts (chapter 1), examine different flows (chapter 2) and draw key messages for policy makers (chapter 3). It is a review that aims to provide a short overview of key concepts and highlight a rich variety of good practice examples to make the concept of circular economy eco-innovation more tangible.

The report also provides a special feature on the EU Eco-Innovation Scoreboard and Global Eco-Innovation Scoreboard. The special feature links to the kinds of tools available on the EIO website and compares the eco-innovation performance of countries.

Who the report will be relevant for

This report will be relevant for readers interested in eco-innovation, transition management and green economy. It is aimed in particular at policy makers, but is also relevant for business, innovation service providers, academia and interested citizens.

[4] Only around 9% of the companies interviewed understood the term and thought about it the context of business.

1 The circular economy: underpinning the transition to a resource-efficient Europe

What is the circular economy?

The basic concept of a circular economy depicts a model of a production and consumption system that relies on the continuous reuse, recycling and recovery of natural resources. ‘Circular economy’ is “an industrial system that is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models” (Ellen McArthur Foundation 2012). The business case of the model is based on keeping natural resources in the economy for as long as possible while retaining their economic value and technical properties.

A circular economy encompasses and builds on a number of complementary approaches, including eco-design, green manufacturing, waste-to-resources, cascading use, industrial symbiosis, cradle-to-cradle, dematerialisation, sustainable consumption, functional economy, and product-service systems. The roots of these core principles go back to the 1970s and are based on the principles put forward by many thinkers and innovators including Walter Stahel and his performance economy (Stahel 1976), John Lyle and his work on regenerative design, the cradle-to-cradle models of Michael Braungart, bio-mimicry popularised by Janine Benuys or the blue economy of Gunter Pauli.

How do circular economy and resource efficiency relate?

The frames of resource efficiency and circular economy are intimately interrelated. The European Commission’s Roadmap towards a Resource-Efficient Europe (EC 2011) provided an overarching vision of a European economy based on a sustainable use of natural resources. The vision depicts a future when: “Economic growth and wellbeing is decoupled from resource inputs and come primarily from increases in the value of products and associated services” (ibid).

Circular economy offers one of the models of resource flows in a socio-economic system that can underpin the vision of a resource-efficient Europe. The model calls for a radical overhaul of the production system and underlying business models to revolutionise the flow of resources through the economic system. Provided the model is effective in shifting economic activities to sustainable use, recovery and regeneration of secondary resources, it will contribute to decoupling economic growth and resource consumption.

The vision of resource efficiency relates to a broader debate on green economy and sustainable development. Discussions about a circular economy also need to be considered in this larger context. Our understanding of a circular economy is framed in the context of the future vision in the Roadmap to a Resource-Efficient Europe (EU 2011) and the Rio+20 vision of “The Future We Want” (UN 2012), which means that it should be designed to support economic growth and wellbeing while at the same time reducing the environmental impacts related to production and consumption. **A resource-efficient circular economy model needs to be systemic** and consider *both* changes in the production system and in consumption practices and lifestyles.

What is the role of eco-innovation in the transition to a resource-efficient circular economy?

The transition towards a circular economy is expected to bring significant opportunities in creating new, better quality jobs as well as in contributing to more sustainable economic growth. The transition requires significant innovation efforts ranging from the development of new materials or products to the design of new business models. It will also require system innovations that change the value chains underpinning current production and consumption patterns. **This notion of 'innovation', 'change' and 'transition' in business and social practice directly connects the circular economy agenda to eco-innovation**.

Eco-innovation is 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.).

By combining economic and environmental benefits of innovation in practice, eco-innovation enables the shift towards more sustainable business models and production and consumption practices. **Whereas the focus of eco-innovation is on enabling and setting in motion the process of change, a circular economy model describes an alternative economic system that can underpin a future resource-efficient society and economy.** Eco-innovation can enable a systemic process of change.

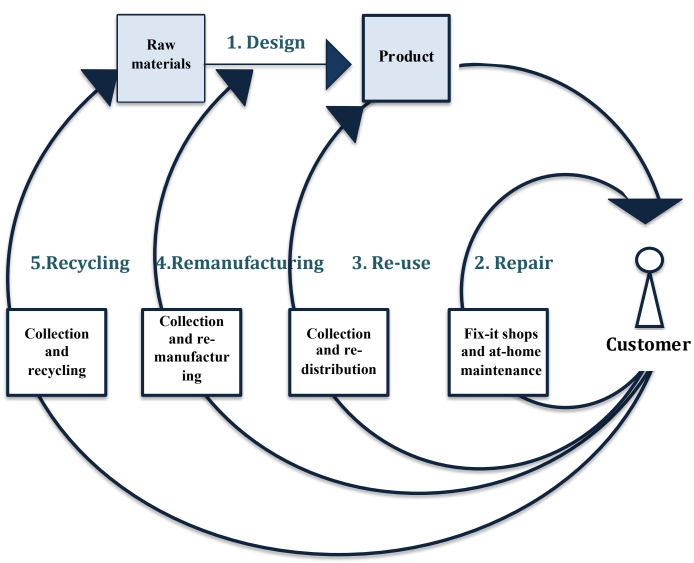
While the shift towards a circular economy can be supported by incremental evolutions within the existing systems -- such as material-efficient manufacturing or improved recycling technologies -- achieving its full potential will require a radical change of the existing production and consumption systems.

How this report examines circular economy

This report is organised around the different flows within the circular economy. It looks at five activities that are crucial to building up successful circular product and material flows across the EU: design, repair, reuse, remanufacturing and recycling. Each step involves different stakeholders, business models, infrastructure and policies and is subject to different barriers and drivers. This report focuses on consumer products and waste, while some business-to-business relationships are touched on. The customer is a key stakeholder in all pathways, emphasising the key role of citizens in the transition to a resource-efficient circular economy.

This is particularly relevant in the context of the eco-innovation challenge, which is to ensure that efficiency gains are not offset by growth in the total consumption of natural resources (EIO 2011). While the circular economy proposes a model to transform resource flows within society, it must be accompanied by efforts to prevent waste, promote sufficiency and decouple the concepts of well-being and life satisfaction from materialism in order to reach the vision set out by the European Commission of a smart, sustainable, and inclusive economy.

Figure 1 Circular economy: depicting the flows assessed in this report



The Eco-Innovation Scoreboard

What is the Eco-Innovation Scoreboard?

The Eco-Innovation Scoreboard (EIS) is a tool to assess and illustrate eco-innovation performance across countries. The scoreboard aims at capturing the different aspects of eco-innovation by applying indicators grouped into five thematic areas: eco-innovation inputs, eco-innovation activities, eco-innovation outputs, resource efficiency outcomes and socio-economic outcomes of eco-innovation.

This structure of the scoreboard assumes an (indirect) link between eco-innovation inputs (e.g. investments) and activities (e.g. the share of companies active in eco-innovation) and the resulting eco-innovation related outputs (e.g. patents). It is also assumed that the generated outputs have wider societal impacts on improving resource efficiency (e.g. increased material productivity) and generating economic benefits (e.g. rising exports from eco-industries).

The EIS is a tool particularly useful for raising awareness about eco-innovation. It allows illustrating how well individual countries perform in different dimensions of eco-innovation compared to the average performance of a reference country group (e.g. the EU or the world). The EIS thus points to areas with strong or weak eco-innovation performance and helps to identify priority areas of action. In order to evaluate the underlying causes for a countries' high or low performance in certain areas as well as to derive specific recommendations for policy or business, other country-specific indicators need to be added to the analysis.

This report presents results for the updated European EIS and, for the first time, presents new EIO activities to develop a Global EIS. The European scoreboard is designed for the EU28 countries and is now available in its 4th edition, completing the time series from 2010 to 2013. The newly introduced Global EIS has been developed for 128 countries world-wide.

Which indicators are included in the EIS?

The 2013 version of the European EIS consists of 16 indicators from 9 different data sources. The indicators are consistent with past versions of the scoreboard (2010, 2011 and 2012) and 13 indicators were updated from the previous year, with most indicators having their latest data available between 2010 and 2012. All updated EU EIS indicators and sources are available in the online EIO database and scoreboard tool. Figure 2 provides an overview of the indicators in the European EIS.

How do the EU-28 countries perform with regard to eco-innovation?

Figure 3 illustrates the aggregated Eco-Innovation Scoreboard for all EU28 countries. The EU28 average is defined as the benchmark and set at a score of 100. Countries with higher performance than the average obtain a score higher than 100 and countries with lower figures achieve less, depending on the deviation from the average.

For illustrative purposes, we clustered the EU28 countries into four groups. Eco-innovation leaders reached scores between 138 (both Finland and Sweden) and 122 (UK) and were thus significantly above the EU average performance across all 16 indicators. All three Nordic EU Member States were part of the top-performing group. Good eco-innovation achievers followed the top-performers with overall scores between 110 (Spain) and 106 (Austria). The third group of average eco-innovation performers reached values between 101 (Belgium) and 91 (Netherlands) and all countries belong to the EU15. The group of countries catching up in eco-innovation consists of all new Member States plus Greece and Portugal. The lowest overall eco-innovation performance was observed for Cyprus (score of 43), Poland (score of 42) and Bulgaria (score of 38).

Figure 2 Indicators included in the European Eco-Innovation Scoreboard

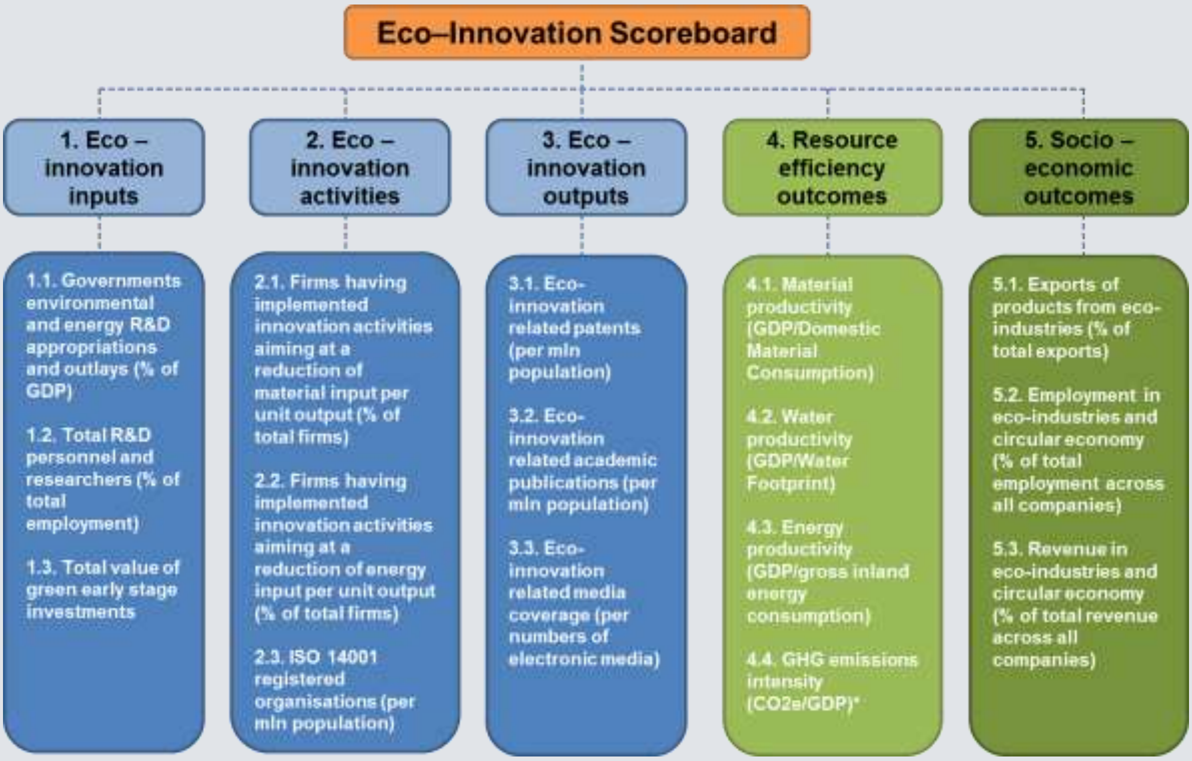
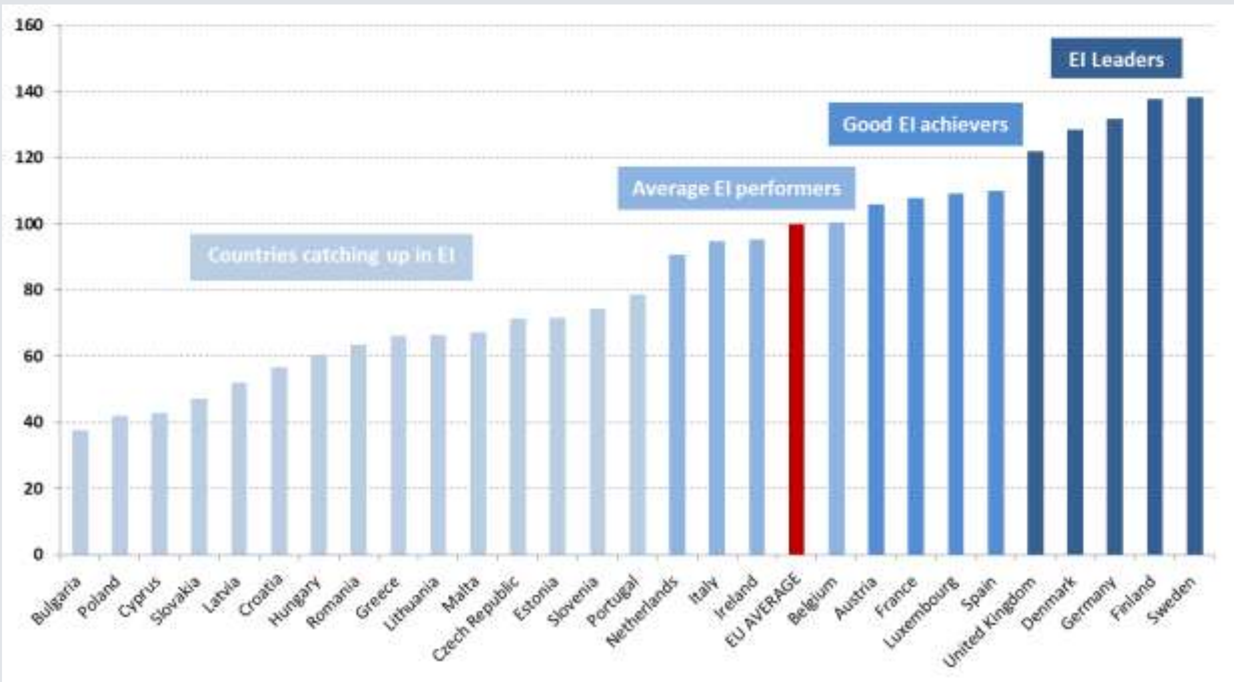


Figure 3 Overall score from the Eco-Innovation Scoreboard 2013 for all EU28 countries



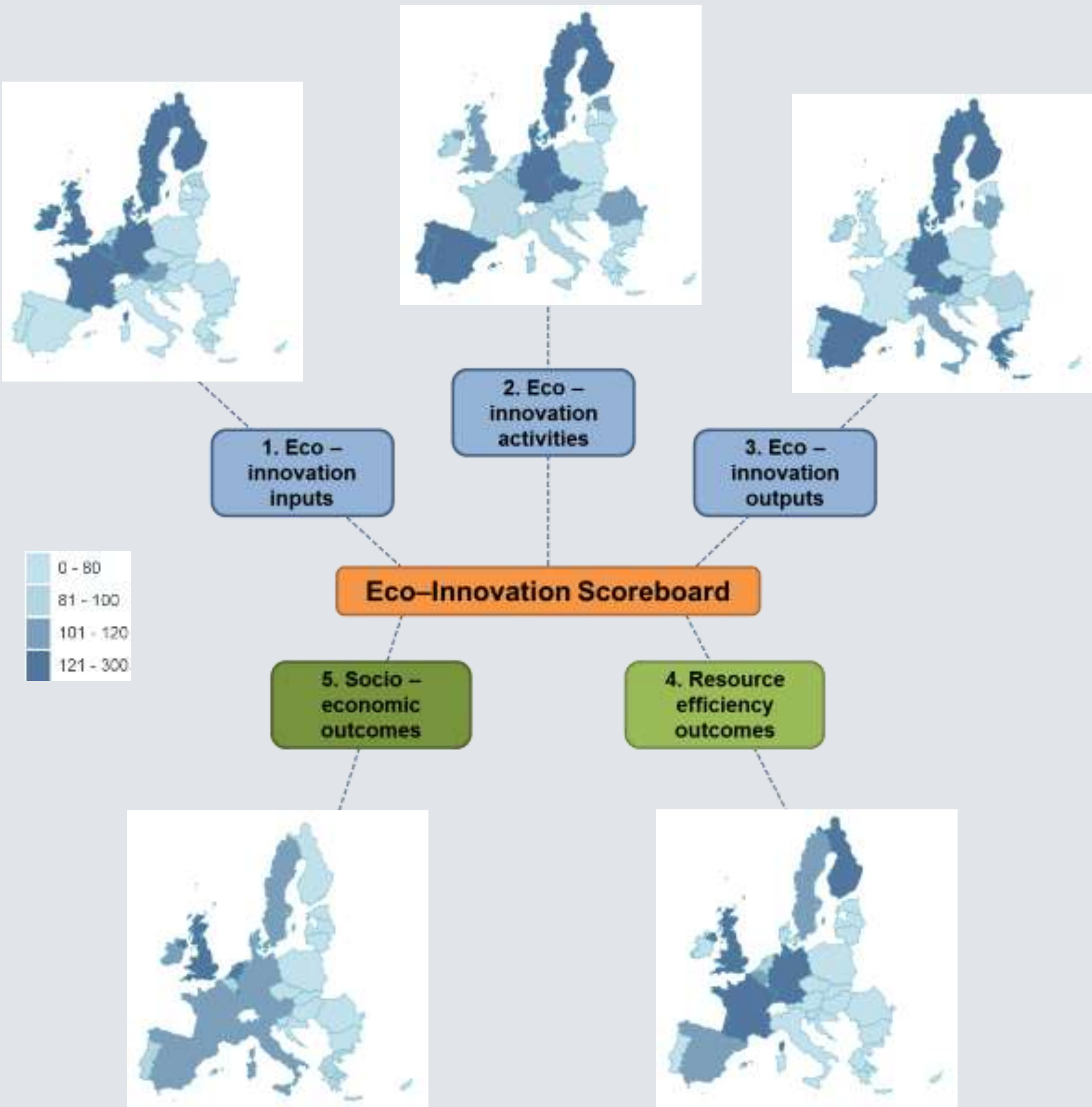
Which thematic areas determine high vs. low eco-innovation performance?

Figure 4 disaggregates the overall scoreboard result into the five thematic areas. Scores are illustrated as EU28 maps and scaled in 4 intervals, ranging from light colour (low performance) to dark colour (high performance).

A close correlation can be observed between eco-innovation inputs and the overall ranking in the EIS. All countries performing above average in the overall scoreboard also had an eco-innovation input score higher than 100. The top two countries, Sweden and Finland, also perform best in area 1 of the scoreboard (184 and 220 scores). Spain was an exception with a relatively low score regarding eco-innovation inputs, due to low volumes of green investments.

Scores in the area of eco-innovation activities were more equally distributed across the EU28 countries, with also Eastern European countries among the high performers. For example, the Czech Republic reached a score of 148 (the third best score in the EU-28), particularly due to the very high number of ISO 14001 registered organisations.

Figure 4 Scores for EU28 countries in the five thematic areas of the EIS



High scores in the third thematic area of the EIS, i.e. eco-innovation outputs, measured with indicators on eco-innovation patents, publications and media contributions, are also concentrated among the best overall performers. Sweden, Finland, Germany and Denmark leading the overall EIS ranking were also the top four performers regarding eco-innovation outputs.

Performance in the area of resource efficiency outcomes was more equally distributed across the EU28 compared to other thematic areas, although the bottom third of countries in the overall ranking generally also had the lowest scores in the area of resource efficiency. It is noticeable that the eco-innovation leaders all performed around the EU average or even below (e.g. Finland only had a score of 77), while the European leaders are UK (134), Luxembourg (129) and the Netherlands (125).

The UK was also the leader in the area of socio-economic outcomes with a score of 143, followed by Germany (136) and France (129). The group of countries catching up in eco-innovation all had a performance far below the EU average.

Individual country performance is evaluated in each of the scoreboard components in detailed country profiles available on the EIO website (www.eco-innovation.eu).

How do European countries perform in the global context?

The compilation of a Global Eco-Innovation Scoreboard allows positioning the EU performance in a global context. The global counterpart of the European EIS follows the same basic structure of five thematic areas, but consists of only 14 indicators due to the fact that some specific indicators are not available on the global level. This concerns particularly survey-based indicators, which are only available for EU countries (i.e. indicators 2.1 and 2.2). A list of indicators and sources in the Global EIS is included in the Annex.

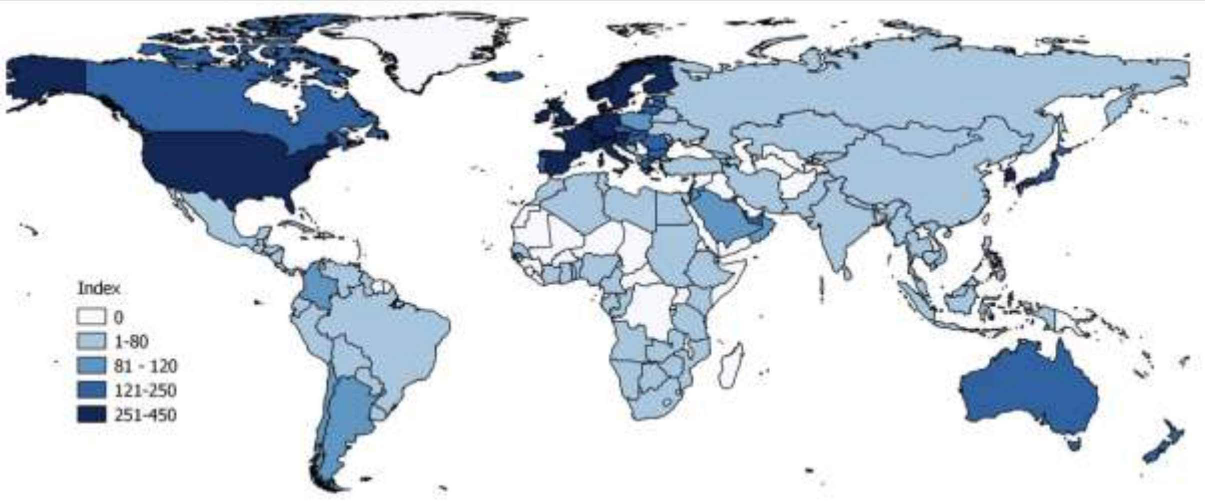
The Global EIS covers 127 countries which have been selected based on the availability of data. For each country included in the Global EIS at least 50% of indicators in the overall scoreboard were available; 69 of the 127 countries had a coverage of more than 70%, 36 countries of more than 90%.

Missing data were not replaced by estimations, i.e. countries for which data is not available did not receive a score for the respective indicator. However, this calculation procedure had no impact on the performance of a country, as the overall index was calculated as the mean of the scores from all available indicators (for more information on the calculation procedure underlying the EIS see the technical description available on the EIO website[5]).

Figure 5 illustrates the Global EIS with 127 countries as a global map. Countries with dark colour have high eco-innovation performance, while lighter colours illustrate lower performance. The average performance across all 127 countries was again set at a value of 100. Due to a different number of countries in the overall index as well as partly different data sources, the values obtained by European countries are different compared to the European EIS.

5 Available at http://www.eco-innovation.eu/images/stories/Eco-Innovation_Scoreboard_2013_Technical_Note.pdf

Figure 5 Overall score from the Global Eco-Innovation Scoreboard



The map illustrates that European countries perform very well when analysed in a global context. The top 15 performers are all located within Europe, with the country ranking led by Sweden (score of 445), followed by Finland (392), Luxembourg (379), Denmark (354) and Germany (344). With a score of 258, the US was the first non-European country found on position 16, closely followed by South Korea (257). Countries with an above global average performance included many of the OECD countries (including Canada, Japan, Australia and New Zealand) as well as some countries in the Middle East (e.g. Saudi Arabia and Kuwait) and some small island states, such as Barbados or Trinidad and Tobago. The BRICS countries were all found in the lower part of the spectrum: China (score of 69), South Africa and Brazil (both 66), Russia (55) and India (40). Among the countries with the lowest eco-innovation performance many African countries were positioned as well as countries in Central and South Asia.

2 Toward a circular economy

2.1 Design

The concept of eco-design[6] has gained increasing interest in recent years. It assumes a new approach to the design of a product with special consideration for the environmental impacts of the product during its whole life cycle. Eco-design is seen as:

"*The philosophy of designing physical objects, the built environment, and services to comply with the principles of social, economic, and ecological sustainability."* -McLennan 2004

It aims to offer new solutions that are profitable, attractive and which lead to an overall reduction in the consumption of materials and energy. **Eco-design is an early step in an innovation process that explicitly aims at developing an eco-innovative product**.

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.

Eco-Innovation Good Practice

JUSIGN modular furniture, Austria

Traditional furniture very often loses its purpose when the user's requirements change. As a consequence they are thrown away. JUSIGN furniture adapts itself to the changing demands and stays a lifelong companion. This modular furniture uses a joining system allowing unlimited combination possibilities for all kinds of purposes. Different types of furniture can be easily built by using the same modules. Furthermore, it is made of high quality to enhance a long lifespan, because its designers and producers want to set an example against the throwaway society. JUSIGN furniture is produced by a Tyrolean carpentry respecting fair working conditions, strict quality controls and highest craftsmanship. It combines function, design, Tyrolean craftsmanship and sustainability.

Source: http://www.jusign.com/main

Opportunities for the circular economy

From a **functional perspective**, design builds the foundation for products catered for a circular economy model. A well-thought out product design can influence every stage of the product life cycle. Design can prepare the ground for low-impact manufacturing and re-manufacturing options as well as ease the separation of raw materials for recycling. A well-designed and durable product may be re-used by multiple citizens. Design can also predefine the selection of sustainable inputs and low-impact materials, as well as optimization of the storage and distribution systems. Changes in design will be most effective, however, if associated with system adaptations, ranging from new business models to changes in infrastructures synced with re-usable products, improved skills and social

[6] Also referred to as sustainable design, environmental design, environmentally conscious design, etc.

acceptance. This suggests that **eco-design is one of the key elements in thinking of and planning a system innovation.**

From an **economic perspective**, design is the kingpin of the following stages. It contributes to making repair, re-use, remanufacturing and recycling less costly and thus more profitable. The 2013 report of the Ellen MacArthur foundation demonstrated that designing and using durable goods, such as cars and vans, washing machines, and mobile telephones, in accordance with circular principles offers materials savings in Europe that could be worth USD 380 billion in an initial transition period and up to USD 630 billion with full adoption. **McKinsey (2012) suggests that product design changes alone could reduce material use by 30%, reducing both costs and environmental pressures.**

Another economic possibility can be seen in the promotion of **new services or product-service system based business models**. Eco-design of a product is one of the core elements of the business models based on repair, reuse, remanufacturing, and recycling. Design can also be helpful by suggesting **dematerialisation based innovative solutions**. This reduction in materials can be for the product itself, the product packaging or the distribution packaging. Dematerialisation can be achieved through miniaturisation or light weighting (Evans 2013, Ljungberg 2005).

Another approach in design is simplification of a product - known as **frugal innovation**. By reducing the complexity and cost of a good and its production, frugal innovation can lead to a reduced use of raw materials and increased robustness contributing to durability (Universe Foundation 2013; Tiwari and Herstatt 2014a,b; Rao 2013). Examples include the Nano Tata car and ChotoKool mobile mini-fridge that are much smaller, lighter, simpler and cheaper than their traditional counterparts, but provide equally good functionality (see EIO 2011 and Tiwari and Herstatt 2014a,b).

Eco-Innovation Good Practice

Modular phone form Google

Project Ara is the codename for an initiative by Google that aims to develop a free, open hardware platform for creating highly modular smartphones. The platform will include a structural frame that holds smartphone modules of the owner's choice, such as a display, keyboard or an extra battery. It would allow users to swap out malfunctioning modules or upgrade individual modules as innovations emerge, providing longer lifetime cycles for the handset, and potentially reducing electronic waste. The first model of the modular phone is scheduled to be released in January 2015 and is expected to cost around $50.

Source: http://www.projectara.com/

Types of Design

The following stages of the product life cycle have the biggest potential for circularity-focused design:

Design for manufacturing: Design can predefine reduced material consumption by developing **resource light products**, as well as alternative or **lighter packaging**, while maintaining high quality. It also influences the way products are manufactured and the type of materials and spare parts used in manufacturing. Application of the **highest quality materials** can improve environmental performance and durability of the product. As regards manufacturing processes, smart design may support material-efficient manufacturing, such as more **efficient** metal blanking, cutting, dosing, waste recovery or other processes (see EIO 2011).

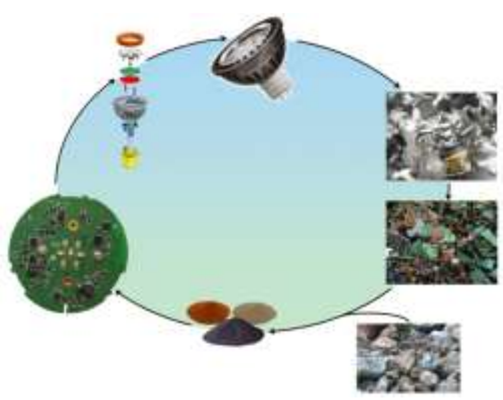
- ***Design for product use***: The concept of **modularity** is key for retaining the value of product components across the life-cycle. Life-cycle modularity entails maintaining independence between components and all life-cycle processes in different modules, encouraging similarity in all components and processes in a module, and maintaining interchange ability between modules (Recchioni et al. 2007, Gershenson et al. 1999). In other words if a product is broken one could replace the broken part (module) instead of a whole product (see example of Project Ara above). Modularity is a move towards ‘component obsolescence’ instead of ‘product obsolescence’.

  Similarly **design can ensure reparability and maintenance** of the product during its use stage and producers can ensure that spare parts are available for sale. The manufacturer is encouraged to take the future refurbishment and maintenance of a product into account by asking questions like whether it can be easily dismantled and reassembled, and whether it is set up in such a way that faults can be easily identified. In designing products for **product-service based models** (e.g. sharing, renting, leasing, pay per service unit), technical and service features that allow such business models to operate smoothly can be incorporated. An example is ICT technologies that help to manage offered services and that provide convenience for customers in connecting with the service provider. Currently, all bike and car-sharing services have ICT as a very important component of their business model.

- ***Design for product post-use:*** Design is pivotal to the post-use options of a product. It means already considering elements such as easy disassembly, secure **purity of materials**, and possibility to reuse components in product development.

Eco-Innovation Good Practice

Better recyclability for Philips lamps



Philips company developed a new lamp prototype for its MR16 LED light bulb which is optimized for recyclability and disassembly. It was a part of the GreenElec project that actively develops the strategies and processes needed for the efficient recycling of electronics equipment. The project came up with an easy disassembly process and possibility to reuse components in new products, secured purity of materials in the recycling process, as well as reduced the overall recycling costs. In this project, the electronic board of the light bulb can be easily upgraded and parts of the lamp can be reused. If the light bulb finally ends up in a shredder, the recyclability and purity of materials are improved because materials are separated.

Source: http://www.hitech-projects.com/euprojects/greenelec/index.htm

Policies addressing eco-design

The EU Ecodesign Directive and the Waste Electrical and Electronic Equipment (WEEE) Directive are the most important EU legislative documents on eco-design in products, supporting notably improved energy efficiency during the use phase.

Other EU directives with an indirect impact on eco-design include:

- ***Restriction of Hazardous Substances (RoHS) Directive***: restricts the use of certain hazardous materials in the manufacture of various types of electronic and electrical equipment.
- ***End of Life Vehicle (ELV) Directive:*** covers aspects along the life cycle of a vehicle as well as aspects related to treatment operations. The aims among others include

preventing the use of certain heavy metals and achieving reuse, recycling and recovery performance targets. However **the literature suggests that there has been limited impact of the ELV Directive on design** (Gerrard and Kandlikar, 2007)

- ***Energy-Using-Products (EuP) Directive***: introduces additional requirements that are potentially more challenging than RoHS, REACH, WEEE. Companies are required to provide ecological profiles of their products, which will require information on material and energy inputs and outputs, as well as information specific to the environmental aspects for each stage of the lifecycle[7].
- ***The Landfill Directive***: it can also indirectly promote eco-design in products by creating incentives to design the product to be more easily reused or recycled in order to save cost of waste disposal.

There are some examples of dedicated initiatives on eco-design on the national level. The Technology Strategy Board in the UK funds competitions on:

- *Design Challenges for a Circular Economy*, aiming to encourage development of materials designed to be re-used, rather than ending up as waste (£1.5m budget),
- *Resource efficiency: New designs for a circular economy*, for feasibility studies into the re-design of products, components (£1.25m budget),
- *Supply chain innovation towards a circular economy,* for collaborative research and development to preserve the value of products and/or materials at end-of-life and to extend their use (£5m budget) (EIO country brief on the UK)

Some countries introduced **extended producer responsibility measures** with a focus on product take back and recycling and related targets, recycling fees, and recycling subsidies.

There are many other possible measures that may strengthen the impact of the Ecodesign Directive in the future, including: durability requirements to increase life span; removing certain substances to aid future recycling practices; undertaking cost effective design measures to improve future recycling (e.g. by avoiding certain coatings or material mixes); providing information about certain critical materials and where they are placed in the product; other types of bill of material (BOM) requirements providing information about materials and substances; longer guarantee periods provided to consumers; maximum disassembly times; requirements to provide evidence that ecodesign was considered during the design process, and requirements on percentages of recycled content in the product (see Dalhammar 2013, DEFRA 2011, Ardente and Mathieux 2012).

Eco-Innovation Good Practice

The Cradle to Cradle (C2C) Certified™ Product Standard

C2C standard is a multi-attribute continuous improvement methodology that provides a path to manufacturing healthy and sustainable products. It guides improvement towards products that are (1) made with materials that are safe for humans and the environment (2) designed so all ingredients can be reused safely by nature or industry (3) assembled and manufactured with renewable, non polluting energy (4) made in ways that protect and enrich water supplies, and (5) made in ways that advance social and environmental justice. C2C CertifiedTM rewards achievement in five categories (Material Health, Material Reutilization, Renewable Energy and Carbon Management, Water Stewardship, and Social Fairness) and at five levels (Basic, Bronze, Silver, Gold, and Platinum). The C2C programme is administered by the Cradle to Cradle Products Innovation Institute which ensure that product certification is an independent and transparent process.

Source: http://www.c2ccertified.org/

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[7] http://www.green-ecosystems.com/energy-using-products-eup.html

Barriers

There are still many barriers hindering wider application of circularity-oriented design practices (Dalhammar, 2013, ENEC 2014, NIBI, 2014):

Policy barriers

- The current polices and regulations are not providing sufficient incentives and comprehensive life-cycle approach to the design for circular economy. The EU Ecodesign Directive that was supposed to address life-cycle aspects, so far primarily regulates energy efficiency during the use phase.
- **Existing regulatory instruments in many countries still have a rather narrow scoping** for eco-design also considering mostly the energy related performance of the products and largely lacking the life-cycle perspective. Existing few standards (e.g. in construction field) are not binding, and thus cannot generate wider and long term impact.
- There is a need for better data, and measurement methods. Many actors are reluctant to set legal standards before these are in place.
- The practice of Green Public Procurement or Pre-Commercial and Innovation Procurement does not fully incorporate the notion of eco-design.

Economic barriers

- There are high costs and risks associated with developing, testing and applying new materials and approaches to design.
- There are **risks related to redefining business models** based on durable products or novel designs (e.g. modularity).
- ‘Eco-products’ are still perceived as niche by many investors and businesses.

Capability barriers

- Companies have product development processes and a position in value chain that do not predispose them to apply novel approaches to design.
- Companies may lack technical knowledge and skills in eco-design and material substitutability.

Cultural barriers

- Risk-averseness and the lack of concern with the environment may become cultural barriers to eco-design in companies.
- The low acceptance of novelty (e.g. modular products) and the **limited openness and trust towards eco-designed products** (e.g. including recycled content) may become barriers on the consumer side, leading to low demand for sustainable products and services.

Drivers

ENEC (2014) has identified the key motivating factors to integrating eco-design into day-to-day activities of companies:

- **Successful pilot ecodesign projects**: successful pilot projects lead to integrating ecodesign into a standard business activity;
- **Company culture and leadership**;
- **Compliance with existing and anticipated legislation**;
- **Competitor pressure** to adopt eco-design;
- Growing **new market opportunities**.

Eco-Innovation and circular economy challenges for sustainable design

- ***Systematic approach considering the entire lifecycle***: Setting the circular economy in motion requires systemic approach. This sets a very complex task for design as it has to incorporate in a meaningful and interlinked way many layers of this system, transform each stage of the lifecycle, and ensure that the circular system is functional.
- ***Business models*****:** The design of business model is important as it describes a value proposition and defines how products and services deliver value to the customer. **Therefore, the technical design of the product needs to be co-developed with the business model deliberation.**
- ***Policy as the main driver of sustainable design*****:** Currently the challenge is to introduce a well functioning policy portfolio that will promote circular economy both from the demand side and the supply side. It is clear that policy and regulatory instruments could be key in promoting circularity in the product design and encouraging business models that will help to reduce material use and prevent or recycle waste through encouraging the longer use of better quality products and shift from product buying to service use. Governments should start addressing this aspect by giving right incentives both to the business and to consumers.
- ***Addressing the consumers' perspective*****:** Circular systems and business models based on new design need consumers who accept new traditions of dealing with products and services. One should not assume that all consumers care about the sustainability impact of a product and are ready to adjust their behaviour to new patterns. Therefore the design of a product and business model which combine convenience, cost effectiveness and attractiveness from a customer perspective are most desirable.
- ***Considering the role of design in relation to enabling wider changes at a system level:*** Designing, developing and implementing system eco-innovation as well as in relation to systemic bottlenecks (e.g. skills, infrastructures etc) are a key challenge for business and policy makers alike.

2.2 Maintenance and repair

There is significant potential to develop innovative approaches to providing maintenance and repair services in the EU.

Repair *(refurbish, reconditioning) is defined as a correction of a specified fault in a product/component and returning it to satisfactory working condition* (Gray and Charter 2007).

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* (Evans 2013).

The role of repair and maintenance has not been explored in relation to eco-innovation, nevertheless their role in service based eco-innovative business models (based on sharing, rental, product-service systems) is significant. **They may also be a focus of social eco-innovations promoting more sustainable social and behavioural changes and more sustainable consumption traditions.**

Eco-Innovation Good Practice

Life-time warrantee and repair as a business value proposition

Briggs & Riley warranties its bags for a lifetime. It will repair a bag for free should it ever break. Of course, such quality does not come cheap; an average suitcase, for example, will cost $320. However, from the lifetime perspective, it makes good economic sense for the consumer and prevents potential waste streams. Other examples include watches from a number of brands, Davek umbrellas, etc, which if found any defect in material or workmanship, or should fail to function properly, a repair is available at no charge.

Source: www.briggs-riley.com

Opportunities for the circular economy

The "Restart" project[8], promoting reuse and repair initiatives, asserts that repair and maintenance are the places where the transformation towards circular economy starts because **they provide innovation space for citizens, small companies and communities**. This means rebirth of local economies of maintenance and repair where libraries, community centres, and markets are used to combat a throw-away culture and fix broken goods.

It has been estimated that maintenance is the most cost effective way of extending products lifetime (Evans 2013). During the product life-cycle, after-sales services and spare parts may generate more than three times the turnover of the original purchase (Wise and Baumgartner 1999). Armistead and Clarke (1992) consider after-sales as a source of competitive advantage and business opportunity for product manufacturing industries. Already now many companies sell products along with the package of services including the maintenance, repairs, diagnostics, helper videos, installation etc. This offers conveniences for the customers, as well as creates new service-based jobs.

While most discussions on repair and maintenance in debates on a circular economy focus on consumer goods, **there is an enormous potential in innovating these services in relation to large infrastructures**, including roads, bridges, building or even off-shore

[8] http://therestartproject.org

structures. It is argued, for example, that in some cases the repair and maintenance of ageing infrastructure or buildings makes better economic and environmental sense than building a new one. In such cases extending the life of industrial plants and infrastructures, especially those requiring large investments, lengthy licensing procedures and public acceptance, can offer big business and societal opportunity[9].

As summarised by Evans (2013), repair and maintenance activities have several benefits that make economic and social sense:

- **Repair and maintenance activities prolong the lifetime of products for the customer which allow avoiding buying new (often and expensive) replacements**.
- Repair has proved to be the most efficient way to retain or restore the system back to normal working conditions
- Integrating repair services in the product can increase the competitive advantage for a company. Furthermore, repaired based business models can also offer extended business opportunities for product suppliers.
- Finally the product repair can provide pollution prevention, personnel safety and waste disposal

Eco-Innovation Good Practice

Repair Cafés, the Netherlands

Repair Cafés are free meeting places and they are about repairing things together and socialising. In the Repair Café visitors can find tools and materials to help them to make any repairs they need including clothes, furniture, electrical appliances, bicycles, crockery, appliances, toys, etc. They can also find repair specialists such as electricians, seamstresses, carpenters and bicycle mechanics. Visitors can bring their broken items from home and together with the specialists they start making their repairs. They can also just help others to fix things, chat, have coffee and read books on repair available in the Café. The Repair Café was initiated by Martine Postma. Her very first Repair Café organized in Amsterdam in 2009 was a great success. This prompted Martine to start the Repair Café Foundation. Since 2011, the foundation has provided professional support to local groups in the Netherlands and other countries wishing to start their own Repair Café. Today in the Netherlands, there are more than 200 Repair Café groups. Also in other countries the number has grown to over 200.

Source: http://repaircafe.org

Business models for repair and maintenance

Repair and maintenance can be characterised as service innovation. They can play an important role notably in **eco-innovative business models** based on service provision and are 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.

There are also many practices where producers provide life-time guarantee 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”.

[9] Proactive Maintenance Can Work Miracle, Press release, Euromaintenance conference 2014, http://www.euromaintenance2014.org/uutiset.html?6

Social eco-innovation is another space for repair and maintenance activities. New decentralised, grassroots approaches to making and fixing products[10] are emerging. These initiatives are offering opportunities to help individuals fix, as well as experiment and make products. These include tech shops, fab labs, makerspaces focused on makers, and hacklabs and repair cafés focused on fixers. Within hacklabs and repair cafés inventors, entrepreneurs, designers, engineers and hobbyists appear to be coming together to collaborate with a view to extending the life of products through repair and/or changing product functions, therefore extending the use of materials. **In addition, a number of companies and social enterprises are emerging to help citizens and users repair or fix a range of products.** Examples of such initiatives are “repair cafes” (see the Eco-Innovation Good Practice on Repair Cafes in the Netherlands) and “workpace” events (see the Eco-Innovation Good Practice the Restart Project in the UK).

Eco-Innovation Good Practice

Restart Project social enterprise, UK

Founded in 2012 by Janet Gunter and Ugo Vallauri, the Restart Project is a London-based social enterprise that encourages and empowers people to use their electronics longer, by learning fundamental repair and maintenance skills. Moving beyond the culture of constant upgrades and disposal, the Restart Project reconnects people with repair, preparing the ground for a future economy of maintenance and repair. Through community and workplace events the project team offer people opportunities to increase the lifespan of electronics and electrical equipment, thus encouraging consumers to buy for longevity and diverting electronics from “end of life”.

Source: http://therestartproject.org

The possibility for repair can provide inspiration for product developers in the process of design of new **eco-innovative products.** To improve maintenance and possibility for repair such eco-innovative products should presume easy access to parts, fault diagnostics, handling and mounting of parts, safety for technicians, part inter-changeability, identification of components and leads, access to lubrication points, reduced electrical connections, redundancy feature, and final adjustments (Evans 2013). This puts the prospect of localised manufacturing and additive manufacturing, allowing for producing spare parts in various localities, in a context where it can align with a vision of a resource-efficient circular economy.

Maintenance is the most efficient way to retain or restore equipment to its desired level of performance. Proper maintenance has the added responsibility of protecting the equipment from further damage, personal safety and pollution prevention (Evans 2013, Ajukumar, Gandhi 2007). In dealing with technological equipment there are three types of maintenance: (1) preventive maintenance, where equipment is maintained before break down occurs; (2) operational maintenance, where equipment is maintained in use, and (3) corrective maintenance, where equipment is maintained after break down. The latter is often the most expensive because worn equipment can damage other parts and cause multiple damages. Especially preventive maintenance is effective in hindering age related failures of the product and can prolong the operational life.

Novel approaches to repair and retrofitting old buildings and infrastructure can be an important element of strategy that contributes to circular economy. Several studies and projects have demonstrated that it is possible to define sustainable economic opportunities

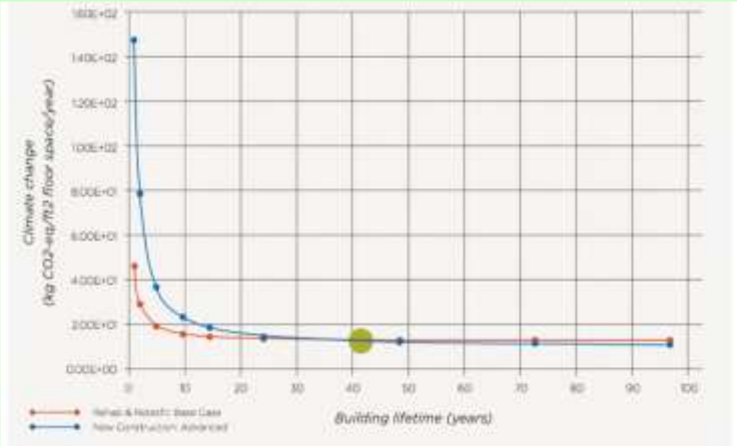
[10] http://cfsd.org.uk/sids/fusion/events/circular-economy-and-grassroots-innovation/

with reinvesting in old building and without consumption of further land and natural spaces. New planning and partnership approaches can boost building re-construction and maintenance sectors, cutting back on further infrastructure and management costs, reducing energy consumption and emissions, saving green spaces around cities and improving urban life quality (USE*Act, 2013;* Preservation Green Lab, 2011; Keivani et al 2010 *).*

Box 1: Environmental value of building reuse

A study by Preservation Green Lab, (2011) finds that in almost every instance, remodeling an old building is greener than building a new one. It showed that it can take decades for a new, energy-efficient building to make up for all the energy that goes into building it. When it comes to climate impacts, new buildings can take 10 to 80 years to catch up to old buildings that have had energy-saving retrofits (see the chart below).

Figure 6 Climate impacts of building new versus renovation of buildings



The blue line tracks the climate impacts of a new building (an office building in Portland in this case), while the red line shows the impacts of a rehabbed older building. The green dot, at year 42, shows the point of "carbon equivalency," when the new building finally makes up for all the energy that went into it and catches the old one.

The full report is available on: http://www.preservationnation.org/information-center/sustainable-communities/green-lab/lca/The_Greenest_Building_lowres.pdf

Who is engaging in repair and maintenance

Many companies are involved in repair and maintenance activities. The major repair and maintenance market is represented by the large infrastructure facilities like railways, trains, airplane, ships and buildings. **The companies and the infrastructure operators** are involved in this market and they will continue playing an important role in the economy, as well as in circular economy.

Every city and town also has **service companies specialising on repair** of appliances, cars, and goods. These are small or medium size companies and they are seen as very important actors in transforming to a circular economy, for example in the US the repair industry including home appliances repair, auto mechanics, car body shops industry, computer repair services accounted for US$ 121 billion revenue, employing around 11 million people in 321 thousand firms across the country[11]. The car repair industry constitutes over 85% of size of total repair industry.

[11] According to the 2013 market research by IbisWorld the US home appliances repair industry had a revenue of $4bln, annual growth of 3.2%, employed 72,792 people and counted 50,467 businesses; auto mechanics industry had a revenue of $60bln, annual growth of 3.2%, employed 537,746 people and had 86,597 businesses, car body shops industry revenue was $36bln, growth 1.4%, had 327,073 people employed, 124,633 companies; computer repair services revenue was $21bln, annual growth -1.2%, employed 153,749 people, had 59,613 businesses http://www.ibisworld.com/industry/default.aspx

Civic and community organisations are emerging as a relevant stakeholder in promoting repair traditions. This is especially remarkable in the context of need to transition towards the circular economy. At the moment their activities are rather informal and based on the grass-root and social enterprise initiatives, but the model they are promoting is gaining interest of the local population (see example of "Repair Café" and the Restart project presented above).

Users, owners of the goods is another important group of actors, as they can obviously do maintenance and repair of their products themselves. They are also the target group of the community initiatives for fixers and makers.

Policies addressing repair and maintenance

Repair and maintenance are not explicitly addressed in the current policies and legislation. The European Waste Framework Directive has obligated Member States to pursue waste prevention, which may potentially lead to promoting repair activities, however no strong supporting evidences have been collected so far.

The WEEE Directive legally binds the producers to take significant responsibility for the treatment and disposal of post-consumer products by (1) reducing the waste; (2) improving and maximising recycling, re-use and other forms of recovery and (3) minimising the impact on the environment from their treatment and disposal. However **the impact of the WEEE Directive on repair as well as reuse is doubtful, as it largely encourages recycling, rather than durability of products**. In particular the Extended Producers Responsibility schemes encouraged under the WEEE Directive currently prevent access to waste by potential reusers and fixers, which led to more direct recycling, landfilling or incineration of the potentially reusable waste products.

Repair is addressed under the **main EU-wide rights as a shopper which provides 2-year guarantee** (which means the seller must repair or replace it free of charge) if a product turns out to be faulty or not as advertised. The two-year guarantee is an EU-wide minimum, and the laws in some EU countries may offer longer limitation periods.

Policies which provide direct support to the repair business or which create a favourable environment for such activities are needed. Setting quality standards that discourage cheap and low quality equipment is another option. The repair industry could also benefit from increasing prices of appliances, which may encourage consumers to have current items repaired rather than replaced. **Improved regulative measures such as reduction of VAT taxes on repair work could make repairs and refurbishment cheaper and boost viability of the repair industry**.

Barriers and drivers

The trends toward increased affordability of consumer goods and mass consumerism, especially in developed and fast growing countries, have diminished product repair practices. One of the reasons for this is that buying a new product became cheaper and more convenient rather then bothering about repairing an old one. **The E-SCOPE survey found that 68% of respondents cited cost as a reason why they did not get items repaired; a factor borne out by the fact that whilst new washing machine prices increased by only 40% during the 1980s-1990s repair costs over this period increased by 165%** (Consumers International, 1998). According to the IBIS World the recovering economy after the crisis will not help the repair industry succeed. As consumer spending revives, individuals will look to purchase new electronics, home appliances, and other goods inhibiting growth for repair services.

It is becoming increasingly difficult to repair products, with electronics and furniture being two cases in point. The design of some appliances makes it impossible to do any repair, which encourages options of discarding the appliance and buying new. Another challenge is the withholding of information by the producers (e.g. incomplete service manuals, appropriate fault diagnosis software and hardware). **Furthermore, many appliances have more integrated components with the need for specific tools to repair it**.

Current polices and regulations are not providing sufficient incentives for repair and continuous use of products. **Existing legislative measures providing incentives to waste recycling may have a rather adverse effect on reuse and repair**. According to RREUSE[12] (2013) once Extended Producer Responsibility schemes have been put in place for waste streams such as WEEE, access to the waste stream for reuse centres in order to separate potentially reusable items is increasingly restricted, leading to more direct recycling, landfilling or incineration of perfectly reusable and repairable products. As recommended by RREUSE, revision of the schemes must ensure free of charge access to the information to reuse and repair centres, not only to those of the after-sales service providers of the manufacturers. It is also very important to guarantee access to spare parts at a reasonable price for a minimum of 10 years and also to design products in a way that does not inhibit their repair.

As regards drivers, the factors discussed above – citizen movements toward repair, the increase of business models using service based models, the emergence of social enterprises – all contribute toward a greater awareness and demand for repair and maintenance. Also the increasing price of raw materials and increasing awareness of environmental issues from both companies and citizens may make business models incorporating longer-lived and repairable products more attractive.

Eco-Innovation and circular economy challenges for repair and maintenance

- ***Making repair desirable for customers***: The biggest challenge in introducing more repair practices is confronting consumerist **culture** in which a quick turnover of (often cheap) goods and buying-throwing practices have become deeply routed. Over the last several decades the repair, as well as renting services of domestic appliances have diminished. Increased affordability made it cheaper to buy a new appliance instead of reparation of an old one.
- ***Making the business case for repair and maintenance***: Traditional economic assumptions of growth based on increased consumption and production still dominate economic development policy. In this economic model quantity (selling more) may bring higher short-term benefits than quality (selling more durable and long-lasting products suitable for repair and maintenance). Repair and maintenance extend the life of products and thus affect the demand for new goods. This may reduce sales and profitability of manufacturing industries geared toward producing and selling “cheap” and low-quality products. The challenge for the circular economy model is to anticipate potential adverse impacts while focusing on capturing new economic opportunities (e.g. shifting manufacturing activity in sectors with a high potential of producing more durable goods toward maintenance, repair and re-manufacturing).
- ***Developing skills****:* Over the last decades the **repair knowledge and traditions have been deteriorating,** especially in economically advanced communities. Maintaining and reviving this knowledge and tradition is one of the challenges in building a circular economy. This could be ensured by maintaining demand for repair activities, encouraging the closed loops based business models and strengthening and revision of the Extended Producers Responsibility schemes. It is also important to encourage social enterprises and community initiatives, as well as educational activities focused on fostering the culture of sustainable consumption.
- ***Linking to wider changes in manufacturing****:* link to localised manufacturing and 3d printing

[12] RREUSE is a European umbrella for social enterprises with activities in reuse, repair and recycling. http://www.rreuse.org

2.3 Re-use

Re-use is key to keeping material flows within the economy. It plays an increasing role in the 7th EAP — the new EU Environment Action Programme to 2020 — and is a critical part of the 3R waste management strategy (reduce, reuse, recycle). The EU Waste Framework Directive has set targets for significantly increasing re-use and recycling by 2020[13] and has defined re-use as:

"(…) any operation by which products or components that are not waste are used again for the same purpose for which they were conceived." – Waste Framework Directive (EU 2008)

Eco-innovation can play a central role in enabling re-use. From the product perspective, re-use relates to aspects like longevity, durability, and reparability, and thus closely links to product design. **Social eco-innovation, user-led eco-innovation and new business models emerge as particularly relevant**. Re-use is linked to social enterprises as well as citizen movements (like the "sharing economy") and relates to changes in consumption and disposal behaviour.

Eco-Innovation Good Practice

Eqosphere, France

Eqosphere is a collaborative web platform that creates links between various stakeholders in the revalorisation of surplus products (food, equipment, textiles, electronics, paper, household items, hygienic appliances etc.) and waste. The platform aims to revalorize surplus and waste produced by supermarkets, shops, warehouses, factories, constructors and craftsmen, restaurants and public services by notifying interested stakeholders (charitable associations, social groceries, animal food production companies, waste management industries, eco-organizations) of their availability. The platform contributes to extending the life of products and promotes corporate social responsibility practices. Eqosphere received the Eco-Innovation Award at the Innovation Competition (2013) organized by the city of Paris.

Link: http://eqosphere.com/#partenaires

Opportunities for the circular economy

In principle, re-use may be relevant for any goods, including both household appliances and industrial machinery and equipment. **Currently re-use focuses mainly on products from private households like clothing, furniture and electrical items and appliances**. It is heavily associated with the increasing availability of second-hand items for sale due to internet platforms and online exchange services (like e-bay) as well as charitable activities. Despite an increasing policy focus on re-use, data, indicators and tools for monitoring re-use trends across the EU are poor. Evidence on the scale of re-use and on economic and environmental benefits is mostly anecdotal in nature.

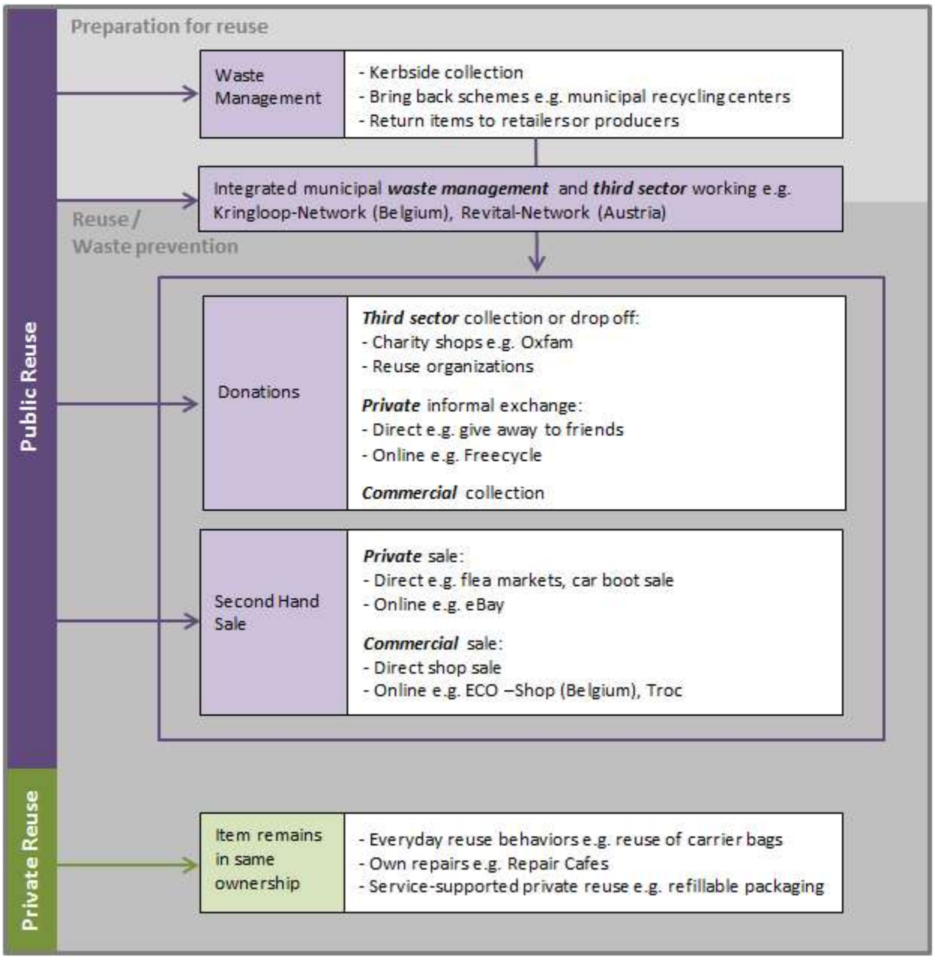
[13] Targets state that "by 2020, the preparing for re-use and the recycling of waste materials such as at least paper, metal, plastic and glass from households and possibly from other origins as far as these waste streams are similar to waste from households, shall be increased to a minimum of overall 50 % by weight; by 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the list of waste shall be increased to a minimum of 70 % by weight." Nevertheless the targets have been criticised for combining re-use and recycling with arguments that separate re-use targets would better stimulate re-use (see e.g. the RREUSE position paper on re-use targets on www.rreuse.org)

Nevertheless, a recent study developed some potential scenarios for resource efficiency potentials in the EU and examined in particular a widespread uptake of furniture and textile reuse (Beasely and Georgeson 2014). For example, assuming that textile reuse will focus on clothing and that cotton and wool represent just over 50% of fibres used in clothing, an ambitious scenario of 35% re-use by 2030 could save at least 14 million tonnes of water. The study estimates that this is equivalent to a week's worth of daily water usage by almost 300,000 people. It would also avoid at least 1 million tonnes of pesticide use and save GHG emissions. **As regards jobs, re-use is labour intensive as it involves collection, sorting, testing refurbishment and reselling**. In the ambitious scenario, the re-use of both textiles and furniture (35% and 45% re-use by 2030 respectively) could create around 300,000 additional jobs (ibid).

Channels for re-use

A recent review (Wilts et al. 2014) depicted possible pathways for re-use within the economy (Figure 7). It illustrates that re-use can take place in a number of ways involving different actors and different levels of interaction with business. For example, **business can provide a service by acting as the intermediary for re-use** (e.g. second hand shops or internet platforms) but may also not be involved at all (as in the case of informal private exchanges). Municipalities play a vital role by providing the infrastructure for collection, be it publicly funded (e.g. municipal recycling centres) or the provision of enabling conditions (e.g. allowance of permits for third sector collection). In all cases, citizens are at the heart of re-use with involvement in each potential pathway.

Figure 7 Channels for re-use



Source: Wilts et al. 2014 based on Arold and Koring n.y., Brook Lyndhurst 2009, Cox et al. 2010, WRAP 2011a, Larsen et al. 2012

Who is engaging in re-use

According to a 2011 Eurobarometer survey (EC 2011), 56% of EU citizens said they would be willing to buy second-hand furniture, 45% would buy used electronic equipment and 36% would buy used textiles (clothing, bedding, curtains, etc.). **Young people (in particular students) and well-educated people were more likely to report a willingness to engage in re-use than older generations and less-educated citizens**. Citizens of Sweden and Finland were the most willing to buy second-hand products while citizens of Slovakia and the Czech Republic were the least willing.

The most common reasons for not buying second-hand products were listed as quality/usability of the product (58% of respondents listed as the main reason), health and safety concerns (50%), less appealing look of the product (25%) and afraid of what others might think (5%). This raises questions as to whether the higher levels of reported citizen engagement in re-use in highly developed countries like Sweden, Finland and Denmark is related to a higher turnover of high-quality products in those countries or whether it is indicative of a 'mind-shift' toward more environmental-friendly behaviour. Both have implications for eco-innovation, with the first indicative of needs for designing more durable products and the second pointing toward a market for new business models capitalising on re-use and up-scaled recycling (e.g. products made from waste like wooden furniture from used pallets).

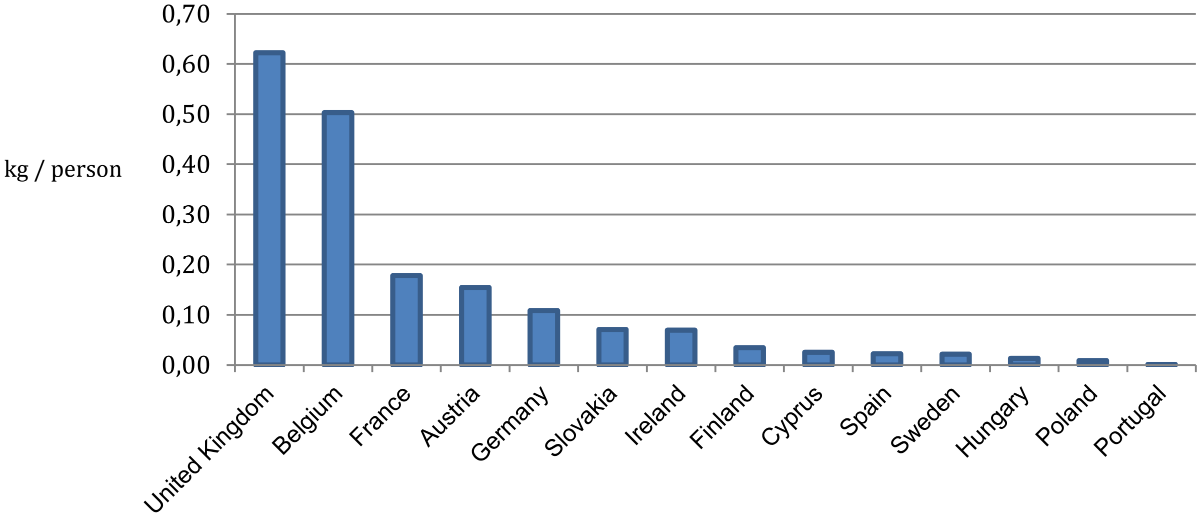
On the other hand, Wilts et al. (2014) pointed out that in many places, repair and second hand have become a niche phenomenon, which primarily targets low-income populations. They attribute this to the increasing complexity of products and shorter innovation cycles, which lead to a quick loss in value of products, in addition to the conscious degradation of product qualities (planned obsolescence) and notable decrease in the technical life cycles of products. According to Wilts et al., "**a subtle but very successful throwaway mentality nowadays prevails in western industrial societies**; the impression is conveyed to the consumer that waste is recycled anyhow, so he/she does not have to worry about topics like repair and reuse." According to anecdotal evidence from Australia, people who have experienced poverty in the past are less likely to purchase second hand because they associate such goods with poverty (Watson 2008).

Data on re-use

There is no data related to the development of eco-innovation in the context of re-use. Data on re-use in general is also poor, but two approaches can be used to provide some evidence on the scale of re-use across the EU. First, from a product perspective, Eurostat provides re-use relevant data for electronic (WEEE-Waste Electrical and Electronic Equipment) and textile waste. Both of these streams are part of the household waste regulated by the Waste Framework Directive, which may be one reason for the better data availability concerning these products.

As regards WEEE, Eurostat provides re-use data for 10 categories (according to the WEEE Directive 2012/19/EU) but data availability remains poor across categories and countries. Figure 8 depicts total WEEE reuse per person in 2010 for the 14 Member States in which data is available. **It shows relatively higher levels of re-use for the United Kingdom and Belgium on a per capita basis, which seems to correspond with policy support and citizen movements seen emerging from these countries.** As regards textiles, Eurostat provides some data on international trade of worn clothing and other worn textiles. Trends from the last few years reveal an increase in this kind of international trade with imports of 0.1 million tonnes and exports of 1.18 million tonnes to and from the EU in 2013. In per capita terms this relates to 0.2 kg/person of imports and 2.3 kg/person of exports (EU-28).

Figure 8 WEEE Re-use in Member States, 2010



Source: Own compilation based on Eurostat data

The second approach relies on gathering bottom-up data from re-use networks. For example, the RREUSE network (Re-use and Recycling European Union Social Enterprises) is a European umbrella organisation representing national and regional social economy federations and enterprises active in reuse, repair and recycling activities. Within the countries that the RREUSE network is active (15 EU Member States and the USA) they estimate that 348,000 tonnes/year have been prepared for re-use. Their main waste streams are electronic devices (305,000 tonnes) furniture (192,000 tonnes) and textiles (133,000 tonnes). Moreover, **they estimate a combined annual turnover of a little over 1 billion Euro with present employment figures around 77,000 people (employed) and another 65,000 volunteers.**

Eco-Innovation Good Practice

Re-engineering Business for Sustainability (REBUS), England

Defra is commissioning action research projects to test innovative approaches encouraging sustainable behaviours: the Action Based Research (ABR) Programme started in 2008 and is an innovative example of open evidence making that is greatly in line with eco-innovation thinking; taking into account the views of all involved stakeholders and involve them in decision making and production of tangible, useable results. The most recent call for project funding was launched in September 2013. An example of a current project is REBUS. Re-engineering Business for Sustainability (REBUS) is a research project funded by Defra within the scheme “Exploring and developing ways to help people increase the useful life of products”, that is one of the headings of the Sustainable Lifestyle Framework (Defra, 2011). REBUS is concerned with the design and implementation of a pilot Product Service System (PSS) based on baby and nursery equipment, such as baby prams or car seats. A PSS is a more sustainable business model because it maximizes resource efficiency by getting more use out of a single product, for example by getting it to be used by more users, such as in a car sharing scheme. As most baby and nursery products are expensive, and used only for a limited period of time, in REBUS the products are being used by more consumers, and refurbished after every use

Source: http://rebus.org.uk

Policies addressing re-use

The European Waste Framework Directive has obligated Member States to pursue waste prevention, which has led to some support for reuse-related measures. Explicit reference to the support of eco-innovation in re-use is not prominent in in policy measures.

Belgium is a good example for an explicit public support to re-use in the EU. OVAM[14] engages with consumers and firms to prevent waste through e.g. incentive programmes, legal obligations, and experience exchange programmes, with re-use centres as a very important channel for immediate re-use by the consumer. Wilts et al. (2014) point out for Belgium that, “Instruments such as a reduced VAT for secondhand products, the regulation that products for reuse are not defined as “waste” (important e.g. for transportation) or the governmental financial support of the reuse centers dependent on the regional reuse rate, are only a few approaches which are in practice to encourage reuse.” In other Member States re-use is also becoming more evident (see also Wilts et al. 2014). Scotland aims to stimulate development in refurbishment and the repair infrastructure as well as to support pilots of collection systems for reusable items. In Hungary, the establishment of technical working groups for analysing the general framework of reuse shall be promoted.

Eco-Innovation Good Practice

SMILE Resource Exchange, Ireland

SMILE Resource Exchange is a free service for businesses that encourages the exchanging of resources between its members in order to save money, reduce waste going to landfill and to develop new business opportunities. Potential exchanges are identified through networking events, an online exchange facility and a support team to assist throughout.

Membership of SMILE Resource Exchange is free for businesses and is project managed by Macroom E. The initiative is supported by the Irish Environmental Protection Agency and several Local Authorities and County Enterprise Boards. The initiative already counts over 1,000 members, mostly SMEs.

The initiative has received wide recognition from the European Commission and has been awarded by the Irish Local Authority Members Association Award as ‘Best Eco-friendly initiative” in 2013.

Link: http://www.smileexchange.ie

Barriers and Drivers

Key barriers and drivers for re-use are related to policy structures, citizen behaviour, as well as technologies and product systems related to lock-ins.

So far, the European approach to re-use has been characterised by single measures instead of an integrated strategy toward re-use in the context of a circular economy. There is a lack of concrete standards and specifications for re-use, which may hamper citizen trust regarding quality and safety of re-used goods. Harris (2012) investigated the

[14] The Public Waste Agency of Flanders; www.ovam.be

market potential and demand for product reuse and highlighted the following measures toward encouraging re-use:

- Introduction of regulatory or financial incentives to encourage re-use
- Consumer and business education to raise awareness of the possibilities for re-use and the benefits
- Introduction of quality standards and accreditation to promote consumer confidence
- The growth of retailer takeback as a service to customers on delivery of new items
- Encouraging leasing and asset management approaches to service provision.

From the citizen perspective, mixed signals related to the current economic system encouraging growth -- often with the underlining business strategy of encouraging customers to buy new and more individualised consumer products -- may contradict support to re-use. **Bringing reuse from niche markets to mainstream markets will require deeper shifts within the social value systems in Europe**. Awareness raising about re-use potential are critical to encourage re-use of old and used products.

As regards technologies, Wilts et al. (2014) point out that in the course of increasingly crosslinking of products, such as the trend of smart homes, the criteria regarding compatibility of reused devices with standards of new technologies is increasingly important. Technical aspects such as repair and upgrade options are dependent on the availability of replacement parts, which points to a need for standardization. Moreover, cooperation options with the original equipment manufacturer can harmonise the information basis and provide future options for repair, reuse and remanufacturing. **This is heavily linked to business models that embrace a long-term perspective and eco-innovation in the design stage**.

Eco-innovation and circular economy challenges for re-use

- ***Developing viable business models:*** Taking advantage of windows of opportunity to make re-use into a sustainable business (e.g. what is the optimum scale of operation, revenues channels, marketing). Also exploring new business models based on private-public partnerships (e.g. social entrepreneurship run closely with local authorities) as well as opportunities to link re-use with frugal innovation.
- ***Shifting from re-use to "up-use":*** Making re-use into 'up-use' by integrating elements of design and remanufacturing (e.g. redesigning old clothes)
- ***Rebound effect related to the consumer society***: Re-use may not automatically lead to a reduction in resource use if it is countered by growing consumption. For example, looking at clothing **there is a risk that cheaper second-hand products lead to higher rates of purchasing** (e.g. buying more clothes that would otherwise have not been bought). There is some evidence of this from re-use in the UK; according to James et al. (2013) approximately one third of reused products are bought in place of new items, and two thirds are either additional acquisitions, or would not have been purchased if second hand items were not available. This means that for re-use to scale up to a societal transition it must be accompanied by a change in citizen behaviour away from the materialistic accumulation of large amounts of stuff and toward the use and re-use of high quality products at a level which can be sustained by loops within the economy.
- ***Environmental impacts related to product age****:* The long term impacts of re-use depend upon the context in which they are implemented (e.g. what is being displaced). For example Prakash et al (2012) consider the environmental impacts of replacing a notebook with a more efficient version. The study finds that "the environmental impacts of the production phase of a notebook are so high, that they cannot be compensated in realistic time-periods by energy efficiency gains in the use phase". The most effective strategies for reducing the impact of a notebook were found to be extension of the useful life-time of a notebook, which could be gained through re-use, possibly after repair. This

is in line with other studies considering the relationship between product lifetimes and energy efficiency improvements for similar products (e.g. Bakker et al. 2014 for laptops and refrigerators). However, it also depends heavily on the age of the product, considering e.g. washing machines older machines may be much less efficient and offer diminishing returns on re-use. This suggests the need for increasing knowledge within society to help citizens better judge when repair and re-use make sense.

- ***Changed behaviour and responsibility for possessions***: Gregson and Crewe (2003) argue that passing goods on to be further used (selling or charity) is partly about the responsibility people feel toward their possessions and whether they recognise persistent embedded value in those possessions. They suggest that a conservative ethics of care is the reason citizens engaged in providing used goods for others' re-use. **For the transition to a circular economy this suggests that people need to feel a connection to the items they own in order to make the extra effort to pass those items on**, instead of throwing them in the bin. The question for eco-innovation is, what kind of products can be designed in such a way today as to enable the re-use culture of tomorrow, and how can this "ethics of care" toward ownership be fostered within society.

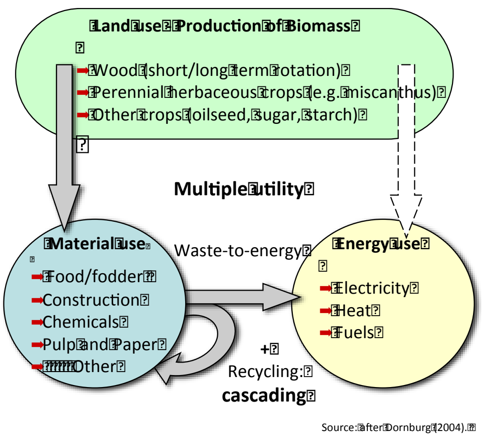
- ***Broadening the scope beyond textiles, furniture and electronics***: Currently the discourse on re-use appears centred around specific consumer product groups. One reason is a policy focus on these groups from a waste perspective. **Expanding the re-use discourse beyond specific streams and products toward actors, behaviours and systems may stimulate more user-led innovations in the private sector as well as in business-to-business opportunities**. Re-use of packaging could be one area for combining new business models with new behaviours (e.g. refill options) and the opportunity for significant resource efficiency impacts could be gained by bringing the re-use discourse more strongly into the construction sector.

Box 2: Cascading use of biomass

Cascades are a form of re-use for biotic resources. Cascading refers to the process of using biomass as a material first, with potentially multiple phases of re-use, before finally recovering the energy content from the resulting waste at the end of its lifecycle. In this way, competition with land, but also with traditional forest industries, would be reduced, leading also to spill-over effects for climate change mitigation. One of the largest barriers for cascading use is competition between material and energetic uses of biomass. For example, forestry, pulp and paper products in Germany have already experienced competition with saw dust, wood pellets and chips for energy use, partly as a result of the financial support for bioenergy applications (Bringezu et al. 2008).

The use of cascades could assist in the innovation processes related to the EU Bioeconomy, which may advance the economy towards fossil fuel replacement (EU Bioeconomy Strategy). While furniture, building frames, packaging, clothing, and paper are already significant biomaterials, bio-based plastics and fabrics are likely to become more important in the future, and cascading could be a strategy to keep these products in the economy longer. Although cascading tends to mitigate the competition between different types of biomass use, few comprehensive analyses of cascading systems have been made. Further research is required to determine the full potential of bio-based materials with regard to sustainable resource use and environmental performance, considering the whole range of biomass use (food, fibre, plastics, fuels). Research is also required for providing appropriate information for policy makers to make better use of cascading potentials by applying proper policy instruments.

Figure 9 Cascading use of biomass



Source: Box based on Bringezu 2009; Figure based on Dornburg (2004)

2.4 Re-manufacturing

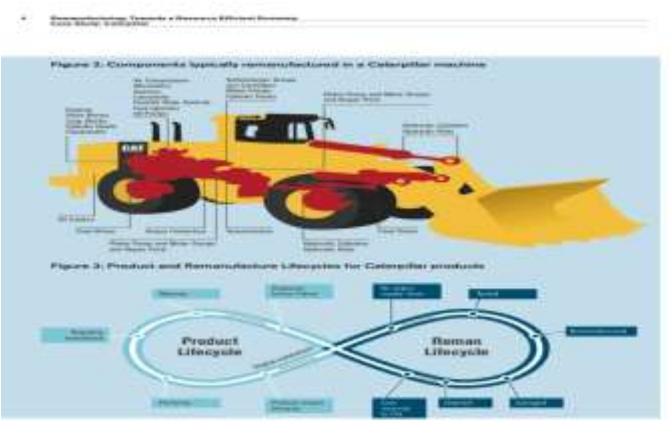
Remanufacturing is defined as:

“A series of manufacturing steps acting on an end-of-life part or product in order to return it to like-new or better performance, with warranty to match.“ - Centre for Remanufacturing and Reuse 2007

Eco-innovation in re-manufacturing is in particular related to changes in product design and business models. A clear benefit of remanufacturing is more flexible business models. A combination of closed product loops and product-service-oriented business models offers greater resilience to economic fluctuations and better capacity to respond to customer needs (Parker 2010). **It also may lead to the development of new strategic partnerships as well as new skills and knowledge, in particular regarding collection channels and reverse logistics**.

Eco-Innovation Good Practice

Caterpillar: “As good as new, as strong as ever”



The Caterpillar business model moto “as good as new, as strong as ever” is indicative of their efforts toward remanufacturing. Catepillar has been remanufacturing since 1973 as it realised that keeping products in-house allowed them to retain ownership and associated value, and reduce material costs. The Figure depicts that approximately 90% of a typical Caterpillar product is left unchanged with 10% being remanufactured. The business model operates as a returns incentive scheme, in which a core deposit economic incentive is used to encourage the return of used parts. The company estimates that its remanufacturing services have led to a 93% reduction in water use, 86% reduction in energy used, a 99% reduction in waste sent to landfill and a 99% reduction in material use compared to making a new product.

Source: Based on APSRG 2014

Opportunities for the circular economy

Remanufacturing has been called a “hidden giant” (Lund 1996) because it operates at a relatively low level of visibility across a diverse range of products and companies, and because it has the potential for substantially contributing to economic growth and job creation. It has been particularly prominent in the United States, where an estimated US$ 43 billion worth of products were remanufactured[15] in 2011, supporting at least 180,000 full time jobs. SMEs are estimated to account for around 25% of the US production of remanufactured goods and 17% of exports (USITC 2012).

Remanufacturing has been making its way over to Europe with lead markets in particular in the UK and, to a lesser extent, Germany. **In 2010 the value of remanufacturing in the UK was estimated at around £1.2 billion**[16] (Parker 2010). According to Laverly et al. (2013) remanufacturing accounts for just 1% of the UK manufacturing sector turnover, but has a

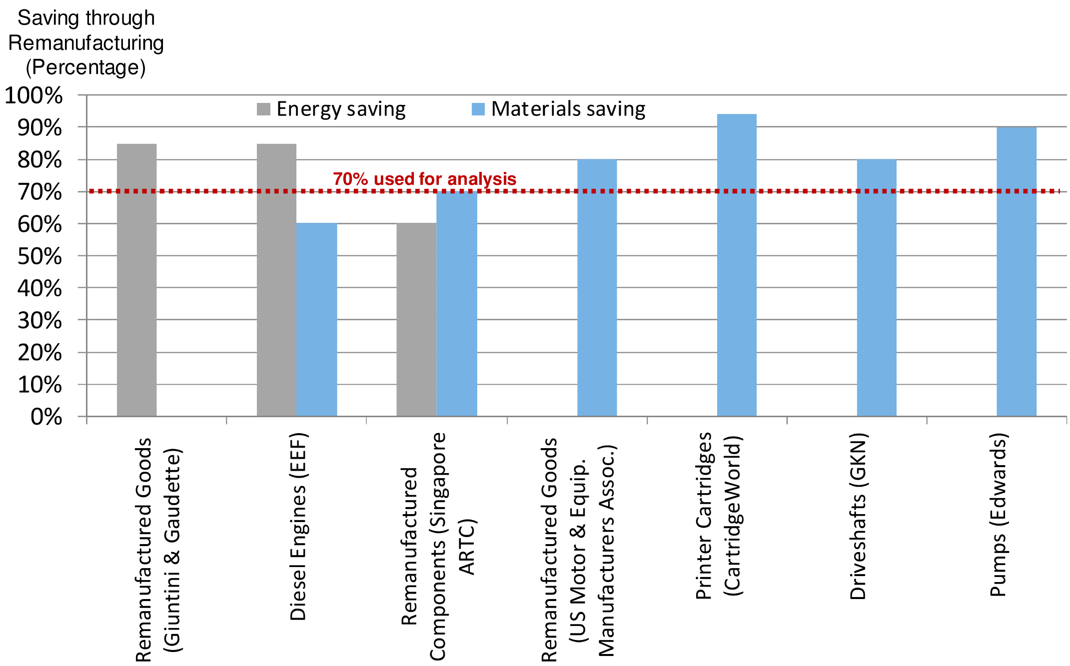
[15] Note that the definition in this is case is slightly different; the report states that remanufacturing is „an industiral process that restores end-of-life goods to original working conditions or better“.
[16] Parker (2010) estimates an economic value for remanufacturing and reuse in the surveyed setors of 2.35 billion pounds.

high potential for future growth; they estimate that the value in just three sub-sectors[17] could reach £5.6 to 8 billion and create 310,000 jobs[18]. **In the US, the price of a remanufactured product is normally between 45% and 65% of the price of a comparable new product** (Lund and Hauser 2012). Taking into account transport and labour costs, Lavery et al. (2013) estimated a net reduction in input costs (goods, materials and services plus labour) of 34% through remanufacturing compared to manufacturing.

The savings of energy and materials are also significant. Figure 10 displays different levels of energy and material savings using actual examples of remanufacturing, with the overarching estimate that 70% of goods, materials and services can be saved through remanufacturing. Estimates from Germany indicate that by extending product life, remanufacturing can save 85% of the energy that went into manufacturing the original product (Steinhilper 2006).

While the potentials seems promising, there seems to have been a slight decline in remanufacturing activities in the UK in recent years. This is mainly thought to be due to economic factors including the economic downturn, the availability of cheap goods and the varying cost of labour (Parker 2010).

Figure 10 Energy and Material Savings through remanufacturing: Case study examples



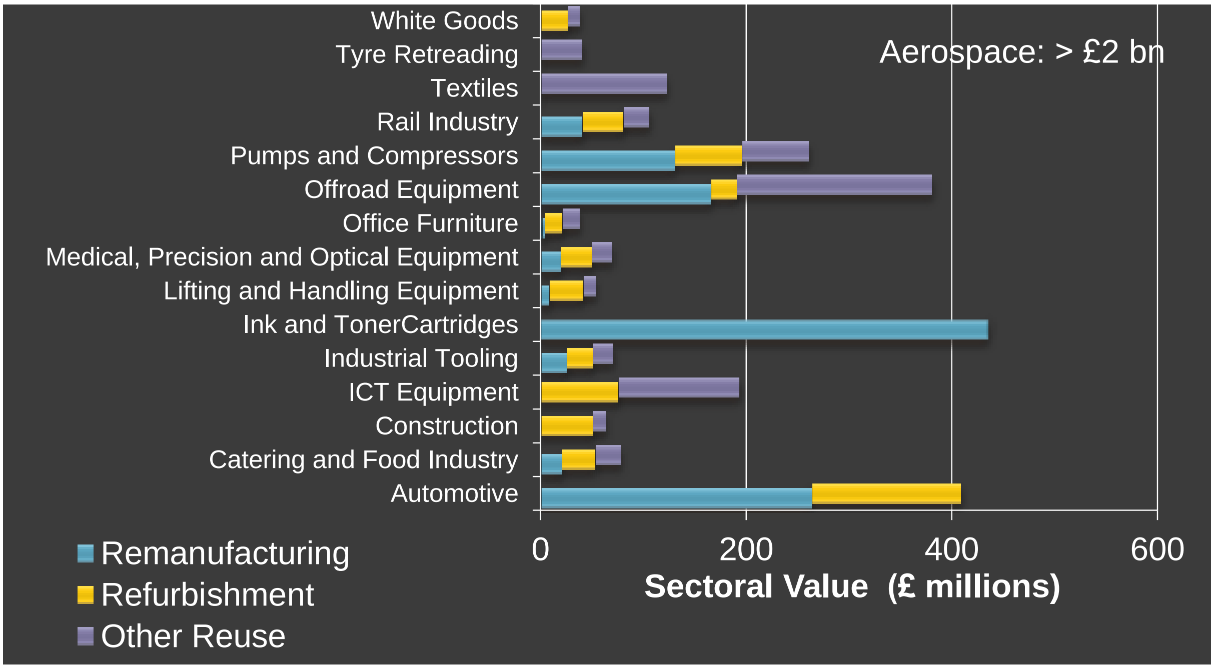
Source: Laverly et al. 2013 based on case study examples from business across the globe

What is being re-manufactured

There is limited evidence on remanufacturing trends in Europe. In the UK, for example, key sectors with remanufacturing activities included **ink and toner cartridges, the automotive sector, pumps and compressors and the off-road sector** (Figure 11). The areas with weak current performance but high potential for future growth are office furniture and medical, precision and optical equipment (Parker 2010). Eco-industries could be also explored for their potential; Allen (2010), for example, points to opportunities of remanufacturing of small and medium-scale wind turbines.

[17] Electrical, electronic and optical products; machinery and equipment; and transport equipment
[18] Remanufacturing is also generally associated with a more skilled labour workforce, which typically leads to higher job satisfaction (Parker 2010).

Figure 11 Sectoral values for remanufacturing and reuse activities



Source: Parker 2010

Note: figures for aerospace industry were not calculated directly as they would not present a fair and accurate representation of the industry due to complexity.

Actors and business models

Three different types of companies are engaged in remanufacturing in the US, each with a different type of **business model** (Lund and Hauser 2012):

- *Conventional* firms purchase cores[19], remanufacture them and sell them to new owners. They may sell directly to individual customers or use retailers (including retail chains).
- *Contract* firms enter an agreement with the owner of a product to remanufacture it and return it to that owner. Typical customers are businesses with fleets, such as trucking companies (tires), airlines (engines), or banks (printers).
- *Original Equipment Manufacturers (OEM)* are manufacturers of a product who also remanufacture their product for resale. They typically sell their remanufactured products through their dealer networks. **Most studies focus on OEMs because they are thought to have unique advantages for remanufacturing, including e.g. feedback on product reliability and durability, reputation, intellectual property protection, brand production, and profitability related to lower production costs** (Matsumoto and Umeda 2011). Most of the benefits as well as barriers and drivers discussed below refer to this type of business model, indicating the need for more research into especially "conventional" firms for the circular economy.

Policies addressing re-manufacturing and policy barriers

A number of the EU's Directives relate to remanufacturing and both promote and hinder the greater uptake of remanufacturing business models. For example, the Directive on End-of-Life Vehicles (ELV) and the Directive on Waste Electrical and Electronic Equipment (WEEE) set targets for recycling and reuse in the automotive and electrical/electronics sectors respectively.

[19] which refer to the units that are to be remanufactured

There is, however, no European level strategy or policy on remanufacturing. Furthermore, the policy framework lacks a coherent approach to remanufacturing in relation to re-use or recycling. This may have undesired effects on remanufacturing.

Policy support for recycling may push supply chain operations towards recycling, even in cases where remanufacturing could make more economic sense. Also on foreign markets, the lack of a common definition of remanufactured goods may influence trade. This is because re-manufactured products are often classified as 'used products' and subject to different regulations (USITC 2012). The development of a clear EU-wide vision for remanufacturing could be a first step on the European level toward greater coherence and understanding of what "waste", "used products" and "remanufactured products" mean.

Re-use targets will not necessarily encourage remanufacturing. For example, Gerrard and Kandlikar (2007) assessed the impact of the ELV Directive and found that while it led car OEMs to take steps toward recycling and disassembly, progress in designing the process for reuse and remanufacturing was limited. One reason could be that no incentive is offered for remanufacturing, making other options such as recycling more attractive (APSRG 2014). Along similar lines, Japan's Home Appliances Recycling Law and End-of-Life Vehicle Law have promoted material recycling but have been insufficient to stimulate remanufacturing within the country (Matsumoto and Umeda 2011).

The EU Directive on WEEE also establishes that producers are responsible for financing the management of waste from their products, leading to varying effects on remanufactures. On the one hand, it may encourage re-use, but remanufacturers that are OEMs must also bear the costs of compliance as original producers of covered equipment (USITC 2012). **Also, in practice, some WEEE may be classified as "waste" which hinders remanufacturing opportunities for, in particular, non-OEMs** (APSRG 2014).

The EU's Restriction on the Use of Hazardous Substances (RoHS) Directive prohibits the reuse of components containing certain substances, which may raise remanufacturing costs for some EU remanufacturers (USITC 2012). It has recently been added to the Directive that if a part of a product is replaced, the whole product will have to be reassessed in order to be awarded the "Conformité Européenne" mark, which APSRG (2012) argue creates a "black box" for remanufacturers.

Business barriers and drivers

A number of barriers have also been identified related to market failures (see Willis et al. 2010). In general, some key business barriers include (based on Parker 2010):

- Declining national manufacturing bases with related shortages in skills
- Availability of low cost products—commonly from Asia—which compete with remanufactured alternatives
- Rising costs of labour, which reduces the economic benefits
- Low purchaser awareness with misunderstandings about product quality
- Increased incidence of lower quality products which has reduced the quality of the core of the product for remanufacturing
- Longer product lifetimes which result in a decline for remanufacturing, but may be positive for the environment
- Complexity of business operations which block uptake by businesses new to the game

The most prominent business drivers relate to economics, in particular in light of rising commodity prices for primary resources. **Traditionally, remanufacturing has not been driven by environmental concerns, but by opportunistic business models** seeking to maximise the lifetime of capital-intensive, durable products and reduce manufacturing costs**.** Environmental concerns leading to a demand for "greener products" may contribute to driving future activities.

Eco-innovation and circular economy challenges for re-manufacturing

- ***New skills and innovation for collection and reverse logistics*:** Current know-how in design (e.g. toward modularity), but also in collection and reverse logistics is poor across the EU. This is a new area for business and a challenge is the creation of innovative solutions for collecting and transporting products for remanufacture in a smart, energy-efficient way, in particular if remanufacturing facilities are geographically far from consumers.
- ***Consumer awareness and acceptance of remanufactured products*:** Remanufactured products are by nature meant for the long term. They may also be more expensive initially. This kind of consumption may require changes in the way consumers interact and purchase products (e.g. buying a printer that will be replaced in a matter years or a printer for the long-term with multiple stages of remanufacture to update it over time).
- ***Mainstreaming remanufacturing business models*:** Moving beyond niche markets and isolated success stories to broaden the scope of products for remanufacturing. Companies may ask themselves how they can revamp their core business model to meet these criteria.
- ***Avoiding future lock-ins*:** A challenge for the long-term is finding a balance between closed loop products now and the innovations of the future. The question is whether setting up elaborate remanufacturing infrastructures for current products “locks” future options for disruptive eco-innovations as remanufacturing may favour incremental innovations.

2.5 Recycling

Recycling is defined as:

"Any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations". – Waste Framework Directive (EU 2008)

Recycling is one of the priorities of the EU resource efficiency policy. It will be at the heart of the European Commission's upcoming Circular Economy Communication[20]. The Communication will define targets and promote development of a more precise measurement and single methodology across Europe on how to define the success of recycling. Current targets established by the Waste Framework Directive (WFD) aim to increase recycling rates of Municipal solid waste (MSW) to 50% by weight by 2020. The new targets will raise the bar to 70% and if met, could de facto prevent landfilling.

Recycling is a well-established eco-industry. Eco-Innovation will be increasingly relevant for developing and improving more effective **recycling technologies** (e.g. processes in recycling facilities) as well as **system eco-innovation in how waste is collected, separated and delivered to recyclers**. It will require combined efforts by citizens, municipalities and industry to develop **an effective system for ensuring that waste streams reach their optimal secondary loop — be it re-use, remanufacturing or recycling**.

Eco-Innovation Good Practice

The Green Laboratory of Recycling, Romania

The Green Laboratory of Recycling is a 2012 initiative launched by the selective waste collection and recycling organisation Eco-Rom Packaging, in partnership with the Ministry of Environment and Climate Change and the Ministry of Education. The project aims to inform, provide education and raise the awareness of the younger generation on environmental issues. Expected gains are to plant the seeds of civic engagement and responsibility towards the environment among children and teenagers. Each year, the project consists of a road show promoting recycling practices in schools a series of cities throughout Romania. Key success factors are the partnership with the local municipalities and the engagement of school teachers in the continuous promotion of recycling. The initiative has been awarded the Golden Medal of Excellency in the SMEs category as part of the European CSR Awards.

Source: http://www.colecteazaselectiv.ro/laboratorul-verde-al-reciclarii-2/

Opportunities for the circular economy

Recycling creates significantly more jobs at higher income levels than waste incineration or landfilling. The EEA (2011) has shown a 45% increase of employment related to recycling between 2000 and 2011. FOEE (2010) estimate that reaching a recycling target of 70% by 2025 could create around 320,000 direct jobs, 160,000 indirect jobs and 80,000 induced jobs in the EU27.

It also contributes to alleviating pressure on ecosystems by lowering the demand for primary resources. In the EU substantial proportions of demand for resource groups like paper and

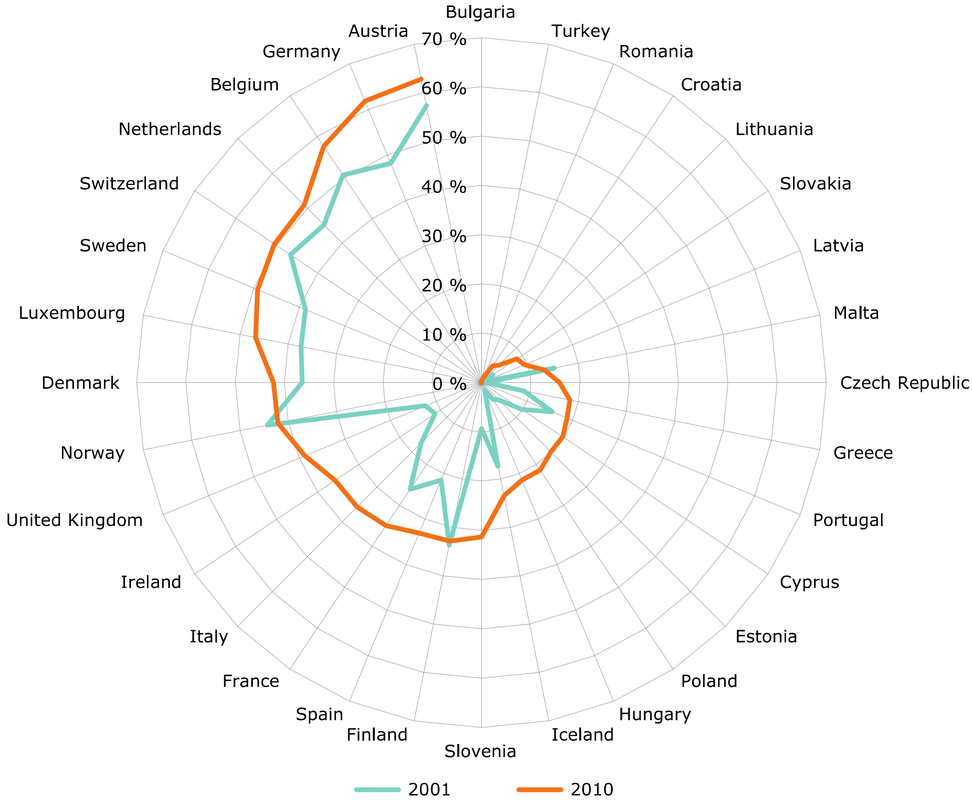
[20] The Communication was published on 2 July 2014 after the present report was finalised.

cardboard and iron and steel are already met through recycling. Future potentials to expand recycling, and the benefits to economy, society and environment, have been explored by a number of studies. For example, Beasely and Georgeson (2014) estimate that around 300 million tonnes of $CO_{2eq.}$ could be saved by recycling 70% of municipal solid waste. With a carbon price of €10 to €40 per tonne this could relate to a monetary value of €3 to €12 billion (ibid, Ökopol 2008).

What is happening across the EU in terms of recycling

Significant improvements in recycling were achieved between 2001 and 2010. Figure 12 shows that 12 countries increased their recycling performance by more than 10 percentage points over this period. Yet, **there are still enormous gaps in performance between EU Member States**. According to the latest Eurostat figures, 27% of municipal waste was recycled, 15% composted, 34% landfilled and 24% incinerated in the EU28 on average. On a country basis, combined recycling and compost rates ranged from 65% in Germany to 1% in Romania (Eurostat 2014). According to the EEA (2013), five countries[21] have already achieved the 50% target set by the WFD and a further six[22] will achieve it if they continue to improve their recycling at the same rate as the past decade. The majority of countries will need accelerated efforts to reach the target.

Figure 12 Municipal waste recycling rates in 32 European countries, 2001 and 2010



Note: The further from the centre in the radar chart, the better the waste management. The recycling rate is calculated as the percentage of municipal waste generated that is recycled. Total recycling includes material recycling as well as composting and digestion of bio-waste. While the comparability of data over time is regarded as high, some break in the time series can influence comparability between countries. For Iceland, 2008 data are used for 2010. For Slovenia, 2002 data are used for 2001 and 2009 data for 2010. Croatia is not included for 2001.

Source: EEA 2013

[21] Austria, Belgium, Germany, the Netherlands and Switzerland
[22] Ireland, Italy, Luxembourg, Slovenia, Sweden and the United Kingdom

Eco-Innovation Good Practice

HOLOFON Zrt. Plastic waste recycling process improvement, Hungary

The research and development project started in 2013 aiming to reduce the amount of waste issued of plastic recycling, and to manufacture new products using the outputs of the technology instead of landfilling them. The currently used technology of plastic waste recycling generates two unwanted materials: a dirty fraction of small plastic particles, mixed with other waste, and wastewater, which is driven to the drainage system. The company Holofon, established in 1995, and treating 12,000 tonnes of plastic annually, wanted to improve the technology in order to avoid the generation of these wasting outcomes. The new method allows not only the optimal treatment of the materials, but results in sanitized and recycled water. Thanks to the new treatment technology of the solid intermediate product various products - such as plastic fence posts, vineyard or special curb - can be produced and sold on the market. The company has a 20 percent market share in the field of plastic recycling, and employs 56 people. Key drivers of the innovation included the New Széchenyi Plan Funds, the increasing level of landfill tax and increasing fee of drainage system use.

Source: http://www.holofon.hu/

Large differences can be distinguished when looking at **different waste streams**. For example, while 19 countries have improved material recycling rates significantly, they barely improved recycling of bio-waste. The EEA (2013) attribute this to a number of potential factors, including the absence of an EU-wide obligation to recycle bio-waste and a lack of quality standards.

Another challenge is the lack of harmonised accounting methods. To implement the WFD countries may chose among four methods to calculate their recycling rates. Using an alternative method, for example, the Irish Environmental Protection Agency has calculated that Ireland has already met the 50% target. Another challenge is within the accounting itself to ensure that the value reported relates to true recycling and not the material collected for pre-reprocessing (e.g. measuring outputs instead of inputs).

Examining recycling rates alone may mask the trend toward “down-cycling”, which means the conversion of “waste” to lower quality products (e.g. plastic recycling to lower grade plastic). The implications from a resource efficiency and a circular economy perspective are significant as it means that the demand for primary raw materials is only slightly reduced and the quality of material are de facto reduced instead of retained. Beasley and Georgeson (2014) suggest that for certain waste streams mandatory targets for the secondary raw material content could be one way to address this process. This does not seem to be such a challenge in established and mature industries like metal, paper and glass sectors, but could be relevant for e.g. plastics.

A second hurdle for resource efficiency is the trend towards increasingly complex products, which makes recycling more challenging. UNEP (2013) describe how traditional recycling focused on specific materials in a “material-centric” approach. Today, aiming to recover one material often results in scattering or destroying another because of the increased complexity of products. For example, up to 60 different elements are used in fabricating a single integrated circuit chip and many of these elements are used as compounds or alloys. The UNEP (2013) report thus argues that a more “product-centric” approach is needed. In particular as **electronic waste has become one of the fastest growing and at the same time one of the most complex fractions of municipal solid waste** (UNU 2008).

This also has implications in relation to mass-based targets such as RMC or TMR. When the aim of recycling is to reduce the amount of waste sent to landfills, targets based on physical weight make sense. However **from a resource efficiency perspective, such targets may miss the objective of recovery of the most resource intensive raw materials (**Bahn-Walkowiak et al 2014). For example, palladium is only about 0.005% of the weight of a mobile phone, but causes 5% of the total material requirements (Chancerel and Rotter 2009). Recycling of palladium could bring significant savings: Saurat and Bringezu (2008) estimate that the secondary production of 1 kg palladium by recycling requires only 4% of the resources.

For the UK, ESA (2013) argues "**many of the 'easy wins' in recycling have been taken**". The study reports that much of the recyclable material which appears in large quantities and homogenous form in waste streams is already recycled (e.g. paper). While a number of potential resources exist in the waste stream (e.g. only 10% of plastic pots tubs and trays are recycled in the UK) dispersion or composition make it harder to collect and aggregate in a cost-effective way.

Eco-Innovation Good Practice

Recicleta, Romania

Recicleta is a social business initiative that collects paper waste for recycling. The organisation employs socially disadvantaged persons to drive cargo-tricycles to collect the paper, thus providing a source of income for the poor. By using the tricycles the initiative reduces its environmental footprint and promotes cycling as an alternative means of transport. The impacts of the initiative include collecting 194,000 kg of paper, saving 2910 trees from being cut and creating 6 jobs for disadvantage persons. This is the equivalent to avoiding the emission of 160.16 tonnes of CO_2 and methane in landfills, and of 3.2 tonnes of CO_2 in the air (due to using cycling as a means of transport). The initiative won the European Investment Bank Social Innovation Tournament Special Category Prize on Environment in 2013.

Source: http://recicleta.ro/

Policies addressing recycling

A number of policy instruments are in place to promote recycling, including e.g. a landfill tax, landfill ban (on e.g. organic waste), incineration tax, mandatory separate collection and economic incentives for recycling (e.g. pay-as-you-throw schemes). Many policies have been introduced in recent years in the context of the Waste Framework Directive (WFD). While the WFD sets very specific technical requirements at an EU level (e.g. a mandatory recycling quota for a variety of waste streams), the institutional setting for waste management differs significantly among EU Member States.

According to the EEA (2013), **countries using multiple policy instruments have achieved the highest municipal recycling rates**. There seems to be a strong correlation between the cost of landfilling and recycling rates. In an examination of waste prevention and waste management policy instruments in 10 Member States from a resource efficiency perspective, Bahn-Walkowiak et al. (2014) concluded that a combination of economic instruments and regulations for technical infrastructure are needed to effectively promote recycling. In particular the analysis of environmental outcomes revealed that regulatory instruments were more effective than economic instruments when waste management incurs costs, as opposed to recycling opportunities were waste management may add value. From a transition perspective, the turning of waste into a resource thus seems to represent the turning point for a circular economy, and is the key challenge for eco-innovators.

A wide variety of policy measures and instruments were highlighted in the EIO EU Country Profiles. These include, but are not limited to, activities in EU Member States such as:

- **Bulgaria:** As of January 2014 the construction of buildings and roads using public funds will mandatorily need to integrate recycled building materials[23]. It is envisaged that by 2020 the amount of recycled materials used in the construction of buildings with public funds to gradually reach 2 %, and in the construction of roads - 10%.
- **Czech Republic:** The National Secondary Raw materials Policy, approved by the Government in 2013, defines objectives for the support of innovations which provide extracting secondary raw materials with a quality suitable for further use in industry.
- **Denmark:** the Danish Ministry of the Environment launched the resource strategy for Denmark called "Denmark without Waste". The objective is to incinerate less waste and significantly increase recycling as well as improve the quality of the recycling process. The strategy foresees ripple effects into other sectors like construction and agriculture.
- **Lithuania** Information campaigns on waste management have increased public awareness of recycling. As a result, more and more people actively and willingly sort household waste.
- **Slovakia:** The introduction of a ban on paper advertising material, which is thrown in piles on top of shells or put in post boxes, aims to reduce the amount of paper waste from promotional material. Recycling centres should also be established for items such as furniture, electronics, textiles, books, CDs and sports equipment and support to home composting given. Amendments to waste management legislation have also raised the fees for waste disposal in landfills (in force since January 2014).
- **UK:** The landfill tax escalator was introduced to assist the UK to achieve its obligations under the European Commission Landfill Directive. Its impact on business has been dramatic with circa a 50% fall in manufacturing waste and a 60% fall in waste to landfill. It has also unlocked the potential of other treatment technologies.

Eco-Innovation Good Practice

BIOLIX project, Belgium

BIOLIX stands for Bio-hydrometallurgical beneficiation of non-ferrous concentrate from shredder residue. The project aims to introduce a set of technological improvements to significantly increase the quality retrieval of precious and rare earth metals (gallium, indium, rare earths) from shredded residues. The partners include Comet Traitements SA (Wallonia) and the University of Liège. Several years of previous research have led to results that will be scaled up and demonstrated. In 2014, it should allow the construction of the first industrial unit capable of processing 4,000 tons of metal per year. Recovery of indium, gallium and rare earths from unusable goods is little, if not at all, developed industrially. Only a few industrial processes exist to recycle production waste of some very specific applications, where critical metals are identified and present in relatively large amounts. The project aims for the recovery of these metals from out of use products, where they are scattered throughout the material, but the importance of the flow available can make it profitable.

Source: Groupe Comet, http://www.cometgroup.be/listing/vente-metaux-ferreux/

[23] as required by the Ordinance for the management of construction waste and use of recycled construction materials

Barriers and drivers

The **lack of an integrated European waste management and recycling infrastructure** hinders coordinated efforts toward the circular economy in the EU. In many countries, like Germany, waste is traditionally viewed from an end-of-pipe perspective characterised by the idea that waste is an environmental burden and cost and should be dealt with locally. However, recycling often requires large amounts of a specific type of waste in order to be economically viable. For example, in the case of integrated smelters for the recovery of precious metals, only six facilities exist around the world. The largest one is located in Hoboken, Belgium, and required investments costs of more than a billion Euros (Wilts 2013). This means that the trade of certain waste streams are often a necessary prerequisite in order to recover materials like platinum, palladium or indium.

Some countries have started to engage in a common European market for waste incineration, which could be further developed into a **European network for recycling at economies of scale**. Examining trade in waste, Wilts and von Gries (2014) found that the total sum of waste exported has increased by a factor of five from 2006 to 2010. This seems to be strongly correlated with waste incineration capacities, in particular in the case of imports to Sweden, which has an incineration capacity higher than the amount of waste generated within the country. The introduction of landfill restrictions and landfill taxes, especially in the Eastern member states, is likely to boost trade in over the next years (Döing and Loenicker 2013). The question is, how these exports will influence waste and recycling infrastructure planning at the interface between national and EU policies.

This question is particularly relevant considering the **competition between waste incineration and, on the other hand, recycling and re-use**. The European Greenbook on Plastic Waste describes a 'vacuum cleaner effect' in favour of waste to energy as one of the most relevant barriers for material recycling. Wilts and von Gries (2014) identified 448 incineration plants in the EU with a total incineration capacity of 76,875,128 tonnes in 2010. These plants seem to be highly concentrated in certain Member States; for example Sweden has an incineration capacity in relation to MSW generation of 113%, the Netherlands of 62%, the UK of 18% and Estonia of 0%. According to a 2010 CEWEP (Confederation of European Waste to Energy Plants) survey, the total incineration capacity in Europe is foreseen to increase by around 13 million tonnes by 2020, in part through the construction of 48 new incinerators (Jafra Sora 2013). Such development could block material recycling in the future. Especially the competition for commercial waste seems to lead to low price levels for energy recovery and may block in particular efforts of the medium-sized recycling industry.

The variety of waste management approaches in EU Member States as well as the diversity in policy choices highlights uncertainty in the general transformation from waste disposal to resource management. **The existing regulatory framework focuses on the volume of waste rather than on its potential material qualities as a secondary resource**. Furthermore, the current risk-averse system of waste management favours waste incineration (which is centrally organised, easy to monitor, and has been tested by years of experience) rather than recycling (Bahn-Walkowiak 2014).

From a company perspective, product design is one of the key technological barriers to recycling. The disassembly and the material separation of products, the avoidance of glue or welding of parts, the availability of spare parts and an index of the materials used in a product would allow for better recycling. In this sense, efforts toward eco-design could become a key driver for recycling.

Past dependencies affect the innovation behaviour of the waste management and waste generating industry. From a business management perspective, a closer look into the selection of applied technologies in the waste generating industry shows that environmental obligations regarding waste can normally be met most easily by direct disposal of generated waste as an end-of-pipe measure. Integrated technologies of prevention or high-quality recycling, which have already been regarded in the production process, in contrast require the conversion of long-time tested and optimised procedures or consumption patterns, which are associated with considerable **technical and economic risks** (ibid). Policy support to overcome these risks and create protected innovation spaces for eco-innovation may, in term, drive recycling activities across the EU.

Eco-Innovation and circular economy challenges

- ***Development of an integrated European recycling infrastructure:*** An infrastructure that encourages networks of recycling -- which have co-developed smart logistics for waste collection, separation and transport together with municipalities, citizens and industry -- is needed to secure waste streams at economies of scale that lower investment risks. **The challenge is shifting the perception of waste as a problem to be dealt with locally to a resource best used at an integrated European scale that maximises opportunities.**
- ***Broadening the scope to waste streams like biowaste and electronics***: While relatively high recycling success has been achieved for certain wastes like paper and steel, the challenge is recycling streams like biowaste and electronics. The latter is strongly linked to design challenges that open up future end-of-life options.
- ***Up-scaling (moving beyond downscaling)***: Innovative approaches to up-scale the materials or components of current waste streams are linked to innovative business models and design challenges (e.g. redesigned furniture from scrap or waste wood). This may require further separation to isolate specific materials and link to the challenge of re-use versus recycling.
- ***Harmonised approach to remanufacture, re-use, and repair:*** Knowledge, infrastructure and tools are needed to help determine the most optimal post-use stage of waste.
- ***Moving beyond end-of-pipe:*** Innovation in the waste sector has traditionally viewed waste as an end-of-pipe problem. In the context of the circular economy, eco-innovation efforts will shift the focus to system approaches that encompass inputs (design) and outputs (waste) in a way that optimises post-use options.
- ***Minimising competition with waste-to-energy***: Waste incineration plants have reduced the amount of waste landfilled in many EU countries; they benefit from an existing infrastructure and time-tested system, which hinders greater recycling efforts aimed at recovery of those same waste streams. One approach is the development of a wider network across countries that could allow incineration and recycling facilities to operate at necessary economies of scale (see above).

Eco-Innovation Good Practice

ZenRobotics, Finland

ZenRobotics Ltd. is the world leader in robotic recycling systems. The ZenRobotics Recycler waste sorting system uses robots to pick raw materials from Construction and Demolition (CND) waste. The system relies on artificial intelligence technology in both identifying the valuable raw materials in the waste, and in controlling the robot's adaptive picking motions. The ZenRobotics Recycler is the first robotic waste sorting system in the world. Thanks to the new ZenRobotics Recycler Semi-mobile product version, the system can now be transported in a standard shipping container, to be installed easily anywhere on Earth for sorting construction and demolition waste. The ZRR Semi-mobile has 2 robotic arms and weighs 20 tons, and is 12 meters long.

Source: http://www.zenrobotics.com/press-releases/zenrobotics-pr_2013-11-15/

3 Key messages and policy challenges

Key findings

The transition to a circular economy will require significant, dedicated eco-innovation efforts. These range from the development of new materials or products to the design of new business models and system eco-innovations that change the value chains underpinning current production and consumption patterns. This notion of 'innovation', 'change' and 'transition' in business and social practice directly connects the circular economy agenda to eco-innovation. .

The report **identified significant eco-innovation potential in the main activities underpinning a circular economy**, including design, repair and maintenance, re-use, remanufacturing and recycling. Eco-innovations with the potential to enable the transition to a resource-efficient circular economy model range from process and product innovation to business model changes and value chain reconfigurations. **Most eco-innovation activities currently take place in market niches on the level of single products and companies**. Out of the activities reviewed, recycling is best established in the current economic system with design and remanufacturing taking an upward trend.

Business models based on the potential of product-service systems are increasingly starting to emerge. These models benefit from combining product or technology eco-innovation with changes in how companies relate to customers or suppliers. Whereas eco-designed products can have significant consequences on the use and end-of-life phase, their full potential can only be realised by changes in the entire business model. Modular design, for example, has to rely not only on a quality product and materials used in a product itself, but also on the way post-sales services, notably maintenance and repair, are delivered. New business models require significant organisational innovation capacities within business operations and structure. Despite emergence of new business models there is very limited evidence on their scale and their wider impact on current material flows.

While incremental evolution within the existing systems -- such as material-efficient manufacturing or improved recycling technologies – are relevant to reaching resource efficiency aims, **the transition to a new circular economy model will require a radical change of the existing production and consumption systems**. With its potential to enable systemic transitions in the way resources flow through economy and society, system eco-innovation has to be a part of any strategy supporting the transition to a circular economy.

Challenges

The main challenge of the shift towards a resource-efficient circular economy is **to enable economic development while reducing the overall use of primary resources**. The vision of long-term sustainability and resource efficiency adds an overall orientation to the model; economies should operate within the safe operating space of planetary boundaries as regards both the **scale** of resource use as well as the **impacts** of production and consumption systems on the environment. The shift to a circular economy designed to align with the overall sustainability objective is an unprecedented innovation challenge.

One of the fundamental observations is that the practical implementation of **the model of a circular economy depends as much on the physical availability and properties of natural resources as on the economic and socio-technical systems** influencing the way resources are extracted, moved and used. This points to the limits of relying only on systemic bio-mimicry in designing economic models. What functions (or can potentially function) well in nature cannot be expected to automatically 'translate' into economic and social practice. **Measuring up the potential of the model of a circular economy has to, therefore, consider how innovation happens in practice and how it diffuses in a path-dependent, interest-laden and often irrational socio-economic reality**.

The review pointed to significant **economic, social, regulatory and infrastructural barriers to eco-innovations with the potential to drive the transition to a circular economy**. Most challenges are of systemic nature and cannot be overcome by individual organisations. Introducing new business models, for example, requires managerial capacities and technical skills within the company, but the major challenges to benefit from the changed model usually lie outside a single organisation. The existence of system lock-ins means that attempts to change the system are likely to meet resistance due to both **tangible limitations** and **socio-cultural configurations.**

One such tangible systemic bottleneck is **infrastructural lock-in**. Costly, infrastructural investments in the past impede changes in the system by making alternative solutions less economically viable from a short-term perspective. These bottlenecks risk locking the economy to a certain path for long periods of time. The demand for waste streams generated by incinerators, for example, may run counter to the vision of a circular economy in which priority is given to re-use and waste avoidance. Furthermore, the investments in recycling technologies and facilities may put similar pressure on the objective of minimising waste and encouraging re-use.

Equally challenging lock-ins are **unfavourable regulatory frameworks, networks organised around vested interests, risk-averse organisational models or value systems underlying choices and practices of producers and consumers**. The most difficult challenge for the transition to a circular economy, and the principal task of policy, will be to overcome systemic lock-ins.

Policy messages

The policy striving for a circular economy needs to be based on **a systemic vision** on how to reach a resource-efficient circular economy. This implies an explicit reflection on the desired roles and dependencies of the major activities in the future model, notably between extraction, repair, re-use and recycling. First, a coherent vision has to take account of **possible rebounds** between these different activities (e.g. re-use versus recycling), their influence on the flows in the system as well as their wider economic and environmental pressures and impacts.

Second, the vision needs to be comprehensive and recognise that a circular economy model will be **internally diverse**. The model will differ depending on the functional area of economy and on the properties and availability of natural resources used to deliver a function or a service. The vision has to portray a set of interrelated functional models of circular economy. While it is not possible to design a mechanistic vision with exact shares of e.g. recycling versus re-use, the roadmap has to be based on a more robust vision and clearly point to the trends and direction of changes preferred by the policy. **An internally coherent policy will require choices about priorities and preferences** that may come at the cost of some other activities.

The policy has to be based on **a comprehensive review of the current policy mix and regulatory framework**. It needs to examine which activities relevant for the circular economy transition have been directly or indirectly supported or favoured. The review conducted for this report suggests there are potentially conflicting visions and measures in the current policy mix at the EU and national levels (e.g. recycling versus waste avoidance). The major difficulty in prioritising e.g. waste avoidance over recycling is the lack of an immediate economic case for doing so.

The findings of this review suggest that **policies supporting the shift to a circular economy geared to support resource efficient economy and society need to embrace system innovation**. Changes on the level of individual companies are necessary but simply not enough to overcome systemic challenges and lock-ins. The system innovation approach has been advocated since the 1990s by innovation researchers exploring technological regimes, technological innovation systems and system innovations (e.g. Kemp et al 1998, Kemp et al 1994, Rotmans and Asselt 2001, Geels 2005, Kemp et al 2006, 2007, Geels 2010).

In order to act upon the challenges and opportunities brought by the shift to a circular economy model there is a **need to understand how the system of innovation functions**. The key elements of the system are **actors**, notably entrepreneurs, who engage in various forms of collaboration that form **networks**, notably supply chains and value chains. The relationships between actors and the forms and dynamics of the networks *co-evolve* within the wider context or framework conditions. **Framework conditions** enable or inhibit, to a varying extent, activities of the actors and networks. They include tangible technical infrastructures and natural environment conditions as well as regulatory, institutional and socio-cultural factors.

The system of innovation geared to support the transition to a resource-efficient circular economy can be portrayed as networks of actors interacting under specific framework conditions to generate, modify, acquire, use and diffuse eco-innovations that keep natural resources in the economy for as long as possible while retaining their economic value and technical properties.

The innovation policy supporting a resource-efficient circular economy needs to **focus on supporting the functions in the innovation system to enable the transition**. Developing a coherent policy supporting the transition will require major policy innovation. Given the scale and complexity of challenges, the innovation policy needs to **combine a systemic approach to adapting framework conditions with a deliberative, concentrated support to selected areas of innovation**. The rationale of revisiting the framework conditions is to design and install the system of incentives and disincentives for different actors engaged in different stages of the innovation process enabling the wider transition. The overall system of incentives should be thought as framing the functions in the innovation system, from the knowledge generation and diffusion to developing positive externalities, in the context of the transition to a circular economy.

In general, the policy supporting system innovation needs to **both adapt framework conditions and focus on supporting system innovation in selected functional systems** (e.g. mobility, food and drink, construction). While not being prescriptive about 'how to get there', the framework conditions, including regulatory framework, need to be clear about the objectives, targets and 'rules of the game' (e.g. criteria, standards, norms). It is the role of policy makers to assure that they do not run counter to the overall objective of the transition. This requires redefining 'level playing field' taking into account the desired future system rather than preserving status-quo. The policy supporting the transition needs to be based on a deliberative political process.

Policy challenges

The functional perspective to innovation systems reveals various **barriers and drivers to system eco-innovation** in relation to different functions. The most challenging barriers are related to **system lock-ins** that can slow down or prevent more ambitious or radical system innovations, often associated with the shift to a circular economy. Analysing and drawing lessons on the existing lock-ins that prevent the desired steps in the transition could improve policy strategies. Policy makers, as well as businesses and researchers, need to take the systemic barriers and drivers into account from the outset in the way they design eco-innovation processes. Similarly, policy makers and other policy stakeholders need to explicitly consider lock-ins in policy design and implementation. This systemic approach will allow a strategic reflection on actual capacities of different actors needed for designing and implementing required changes.

The challenge of concentrating policy support on specific areas requires **the capacity to identify, select and support activities aimed at resolving specific challenges for which public intervention is likely to make an impact on**. This approach requires co-designing with selected stakeholders and deploying a policy portfolio providing a protected innovation space for actors expected to take the highest risk in engaging in innovation processes intended to resolve the challenge. This approach aims to share risk of entrepreneurial experimentation and provide dedicated support to market formation. The selection of the areas could rely on the principle of subsidiarity that implies taking action on the optimal level for the intended results.

The transition will have **different dynamics and timescales in different geographies**. Eco-innovations, just as any other technological and non-technological innovation, will emerge and diffuse differently in different locations. Taking into account the geographical dimension is particularly relevant for changes towards a circular economy system, notably for understanding dynamics of supply and value chains. The wider diffusion of new solutions or business models will be slowed down, for example, by the predominant socio-technical systems in some regions or cities, such as recent investments in incinerators that rely on certain waste streams.

The changes will take place over diverse **time scales**. On the one hand, the timescales will depend on the nature of the innovation process in a socio-technical system or a sector. Innovation cycles, for example, differ between the pharmaceutical industry, where research and testing phases of new drugs can span years, and the fashion industry, where the innovation cycle can close within months. The nature of natural resources used in a given socio-technical system is one of the factors determining the process. In the case of the transition to a circular economy, the accessibility to resources, dynamics of resource flows or properties of materials should be considered among key determinants of the innovation process. Knowledge on the durability of infrastructures, for example, becomes a key factor in taking decisions on a *right timing* for investing in innovating the design and construction of new or modified built environment elements.

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Annex I

Overview of indicators in the Global Eco-Innovation Scoreboard

Name of indicator	Source	Year	Country Coverage
1. Eco-innovation inputs			
1.1. Governments environmental and energy R&D appropriations and outlays (% of GDP)	OECD	2012	34
1.2. Total value of green early stage investments (USD/capita)**	Cleantech	2010-2013	46
2. Eco-innovation activities			
2.1. Number of ISO 14001 certificates (per 1000 population)	ISO Survey of Certifications	2012	156
2.2. Companies engaged in eco-industry activities (% of total companies)**	Thomson One	2010-2013	67
3. Eco-innovation outputs			
3.1. Number of environmental patents (per mln population)	Patstat	2011	227
3.2. Number of publications (per 1000 population)	Scopus	2012	227
3.3. Eco-innovation related media coverage (per mln population)	Meltwater	2013	91
4. Resource efficiency outcomes			
4.1. Material productivity (GDP/Domestic Material Consumption)	SERI/WU/ifeu Global Material Flows Database	2009	179
4.2. Water productivity (GDP/Water Footprint)	Water Footprint Network	1996-2005	172
4.3. Energy productivity (GDP/gross inland energy consumption)	International Energy Agency (IEA)	2011	132
4.4. GHG emissions intensity (CO2e/GDP)	World Resources Institute (WRI)	2010	183
5. Socio-economic outcomes			
5.1. Environmental Goods (EG) share in total trade (% of total exports)	UN COMTRADE	2012	163
5.2. Employment in eco-industries and circular economy (% of total employment across all companies)	Thomson One	2012*	70
5.3. Revenue in eco-industries and circular economy (% of total revenue across all companies)	Thomson One	2012*	49

Note: Data on early stage investments were kindly provided by Cleantech Group (http://www.cleantech.com)

* In the Thomson database the last reporting period data was from 2012, but there were exception for a few companies that provided data for the last available year which are earlier years.

**Tentative indicators (under development or depending on external data).

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