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Annex 1: Results of literature review

Scoping study to identify potential circular economy actions, priority sectors, material flows & value chains

Funded under DG Environment's Framework contract for economic analysis ENV.F.1/FRA/2010/0044

Literature review synthesis

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I. Objectives

This literature review has been prepared under the project '*Scoping study to identify potential circular economy actions, priority sectors, material flows & value chains*' for the European Commission[1]. The Terms of Reference of this study highlights that it should complement existing literature on circular economy by focussing the analysis on EU policy needs, and by identifying value chains, sectors/ products and material flows to prioritise in policy interventions. The literature review aims to identify and review selected key literature related to the circular economy, in order to:

- Define clearly what the concept 'circular economy' embraces, as a circular economy has many different dimensions and can be envisioned through different approaches;
- Gather the existing evidence on the key obstacles to the implementation of a circular economy, and related policy enablers and barriers;
- Outline pre-existing prioritization of value chains, material flows, sectors / products from a circular economy perspective, and weigh the environmental and economic impacts associated with circular initiatives in such sectors.

This literature review is a first step in assessing the potential environmental and economic costs and benefits of implementing a circular economy model in the EU. It contributes to identifying and classifying the industry, consumer and policy challenges that the European Commission could address, and provides inputs for which value chains, material flows, and sectors could be most pertinent in relation to a circular economy.

[1] Under DG Environment's Framework contract for economic analysis ENV.F.1/FRA/2010/0044.

II. Methodology

To conduct this literature review, the project team has first identified over a hundred publicly available studies from recent scientific and grey literature, related to the implementation of a circular economy and related topics. The search for literature was based on sets of key words (e.g. circular economy, remanufacturing, sharing economy, cradle-to-cradle, industrial symbiosis, product service systems, etc.) and performed in search engines such as Science Direct, Google Scholar and websites like the Ellen MacArthur Foundation website. In addition, the review of publications led to the identification of additional relevant articles and documents.

The reliability of the sources (e.g. academics, governments and agencies, business and industry, civil society) has been thoroughly assessed, and studies have been classified and organised in a document according to the following aspects of interest, in order to be selected (or not) for a further review:

- The study provides a definition of Circular Economy (yes/no);
- The study provides a life-cycle perspective of products and value chains (yes/no);
- The study provides case studies of priority sectors, products or value chains (yes/no);
- The study provides a quantitative impact assessment and analysis of costs/benefits in case studies (yes/no);
- The study outlines key barriers/ drivers and policy strategies for the development of a circular economy (yes/no).

After this classification, the project team analysed in-depth the fourteen most relevant studies, (see Annex 2VI.1) taking into account the above criteria, and has compiled short (approximately 4-pages) summaries for each of these selected references.

III. What is a circular economy?

A. Context

The linear approach to industrialisation ('take-make-dispose' industrial processes[2]) is wasteful of both resources and money, and therefore places an unnecessary pressure on the environment. Waste generated by economic activities is increasing. In light of a volatile market where critical resources or materials[3] will eventually become scarcer and more expensive, recycling has become indispensable. However, this is not enough and the promotion of new economic models that work in a closed loop is necessary to minimise material and energy losses. More generally, we will have to find ways that lead to greater prosperity for more people and that put less pressure on the environment in absolute terms – what is generally referred to as 'absolute decoupling' (Schütz and Bringzu 2008).[4]

Inspired by the functioning of natural ecosystems where "nothing is lost, everything is transformed"[5], the concept of circular economy has emerged in a context where it becomes increasingly more important for all economic actors to improve the management and efficiency of resources and to secure their long-term supply, by moving away from a linear supply chain, i.e. from a 'take-make-dispose' economic model.

The fourteen studies analysed in-depth in this literature review have enabled a working definition of a 'circular economy' to be provided.

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[2] *Towards the circular economy: Economic and business rationale for an accelerated transition*, EMF (2010)

[3] In 2010, the EU published a list of 14 critical raw materials, the so called EU-14, materials on which the European economy depends but which might be at risk of supply disruption (cobalt, beryllium, neodymium, terbium, etc.)

[4] See the index of www.eco-innovation.eu

[5] "*Nothing is lost, nothing is created, everything is transformed"* is paraphrased from a statement of Antoine Lavoisier, in his *"Traité Élémentaire de Chimie"*. Lavoisier was a French nobleman and chemist central to the 18th-century, who considered that although matter can change its state in a chemical reaction, the total mass of matter is the same at the end as at the beginning of every chemical change.

A. Defining circular economy

Circular economy represents a development strategy that enables economic growth while optimising consumption of resources, **deeply transforms production chains and consumption patterns**, and **redesigns industrial systems** at the system level.
The circular economy aims to keep the value added in products for as long as possible and to cut residual waste close to zero. It could therefore be considered as a regenerative system[6], which retains the resources within the economy in contrast to the currently prevailing 'linear' model of extraction, manufacturing, consumption and disposal.
Moving to a circular economy requires changes in all parts of the value-chain, from consumer demand, through product design, new business models and new ways of turning waste into a resource. It implies a fully systemic change, affecting all stakeholders in the value chain.
Innovation, in all its forms – technological, organisational, and social – is one of the main drivers of the circular economy. A circular economy **closes 'resource loops'** in all economic activities in a sense that there is no 'end' within a circular economy, but a 'reconnection to the top of the chain and to various activity nodes in between'[7].

Circular economy strategies are schemes ensuring that upstream decisions in the value chain are coordinated with downstream activities and actors. They connect producers, distributors, consumers and recyclers, link incentives for each of these actors, with an equal distribution of costs and benefits.

If circular economy aims to "design out" waste, it goes beyond the approach of waste prevention and waste reduction.[8] It aims to inspire innovation throughout the *whole* value chain, rather than relying solely on waste recycling at the end of value chains. The studies which go the farthest in defining the circular economy concept (and not those which limit its definition to waste reduction and prevention) state that it is based on **two pillars**:

- **The 'cradle to cradle' principle**[9], which is twofold:
    - **Product design for durability, disassembly and refurbishment**: businesses should apply the principles of eco-design to all their products, i.e. use as little non-renewable resources, eliminate as many toxic elements and hazardous materials as possible, use renewable resources (at or below their rates of

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[6] *Towards the circular economy: Economic and business rationale for an accelerated transition*, EMF (2010)
[7] *Reinventing the wheel: a circular economy for resource security*, Hannah Hislop and Julie Hill, Green Alliance (2011)
[8] *New business models for a radical change in resource efficiency*, Uwe G. Schulte (2013)
[9] *Cradle to Cradle: Remaking the Way We Make Things*, McDonough and Braungart (2002).
Cradle to Cradle is a biomimetic approach to the design of products and systems, which models human industry on nature's processes viewing materials as nutrients circulating in healthy, safe metabolisms.

regeneration), increase the life and reuse potential of products, and facilitate, at the conception stage, the sorting and final recovery of products.[10]

  - **"Modern circular and regenerative forms of consumption,** from anaerobic digestion of household waste to product recovery."**[11]** Furthermore, models of consumption should change **from buyer to user**.

- **Industrial symbiosis :**
  - A **cross-sector approach** and a **cooperation between actors** unaccustomed to cooperate (e.g. between products designers and recyclers), **along the whole supply chain of a product**, in order to optimise its life-cycle. It is the sharing of services (e.g., transport[12]), utility, and by-product resources among industries **in a territory**, creating synergies between businesses for economies of scale. The **spatial clustering** of collaborating companies is highly important as it makes the interconnecting of links in the supply chain and the exchange of residuals between links easier.[13] However, in some cases exchanges are possible also at a geographical distance.[14]

The pioneer city of Kalundborg in Denmark gave the first example of an industrial symbiosis initiative, in the 1970s, by creating synergies between public and private enterprises, through the exchange of waste, water, materials (raw and recycled), and energy, and by sharing "support" services such as logistics, transport, and various services to employees. In the system, an oil refinery, a company producing plaster, a pharmaceutical company, a fish farm, a coal-fired power plant and the municipality have been working together. Surplus heat from the power plant is used to heat 3 500 local homes in addition to a nearby fish farm, whose sludge (from processes and the fish farm's water treatment plant) is then sold as a fertilizer for nearby farms. Steam from the power plant is sold to Novo Nordisk, a pharmaceutical and enzyme manufacturer, in addition to Statoil power plant. This reuse of heat reduces the amount of thermal pollution discharged to a nearby fjord. Additionally, a by-product from the power plant's sulphur dioxide scrubber contains gypsum, which is sold to a plasterboard manufacturer. Almost all of the manufacturer's gypsum needs are met this way, which reduces the amount of open-pit mining needed. Furthermore, fly ash and clinker from the power plant is used for road building and cement production.[15] These exchanges, illustrated in Figure 1, have enabled a reduction in intermediaries, generated economies of scale and reduced transport costs induced in production processes for all stakeholders.

[10] *Economie circulaire, écologie industrielle, Eléments de réflexion à l'échelle de l'Ile-de-France*, IAU (2013)
[11] *Towards the circular economy: Opportunities for the Consumer Goods Sector*, EMF (2012)
[12] On this subject, see *Dutch Logistics 2040, Designed to last* , Council for the Environment and Infrastructure study (2013)
[13] *Opportunities for a circular economy in the Netherlands*, TNO (2013)
[14] Implementation at UK level of the National Industrial Symbiosis Programme
[15] *"Industrial Ecology in Practice – The Evolution of Interdependence at Kalundborg",* J. Ehrenfeld and N. Gertler (1997), Journal of Industrial Ecology (p. 67-79)

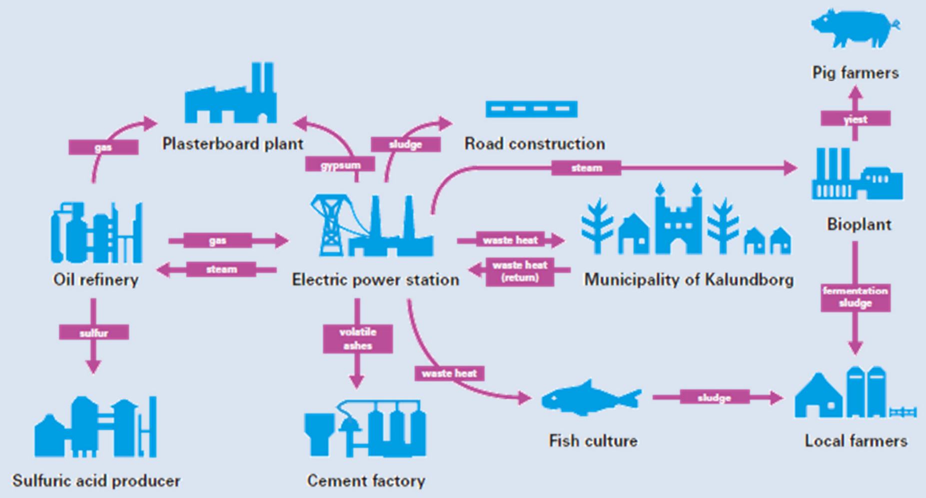

Figure 1: Industrial Ecosystem at Kalundborg, Denmark[16]

B. Circular Economy "loops"

When applying circular economy concepts, resources in general can be distinguished into two categories:

1. **Technical materials** like minerals, metals, polymers, alloys and hydrocarbon derivatives (e.g. plastics), which are not biodegradable and are based on finite resources.
2. **Biological materials** such as food and wood products, which are non-toxic and can be safely returned to the biosphere, where they act as nutrients.

The distinction between technical nutrients and biological nutrients, inspired by the literature, is not always clear (e.g. case of bioplastics). Furthermore, although **circularity** typically brings to mind the capture of such material flows, **a few studies equally apply the concept to the management of energy and water resources** within a closed loop economy. However the management of water has not been discussed further in this synthesis, and there is only limited focus on the management of energy**.** This is because most of the literature on circular economy focuses on technical and biological nutrients.

One of the founding principles of a circular economy is that waste should be minimized or virtually eliminated as it is "designed out" [17]**,** of economic activities. In other words, the biological and technical components of a product are "designed by intention to fit within a materials cycle, designed for disassembly and re-purposing".[18]

[16] *Industrial Ecosystem at Kalundborg*, *Denmark*, Peck, S. W. (1996)
[17] *Towards the circular economy: Opportunities for the Consumer Goods Sector*, EMF (2012)
[18] *Towards the circular economy: Economic and business rationale for an accelerated transition*, EMF (2010)

This section presents the conceivable material loops a circular economy aims at creating. It presents technical nutrients and biological nutrients in turn.

1. Circular Economy loops for technical nutrients[19]

There are four means[20] of achieving a Circular Economy for technical nutrients in descending order of value of outcome:

i. **Reuse of goods**:
   a. A product (whether intermediate or final) is used again ("as-good-as-new"), for the same purpose as in its original form or with little enhancement or change.
   b. A product (whether intermediate or final) is used again for a different purpose than its original form with few or negligible improvements.

ii. **Product refurbishment or component remanufacturing:**
   a. *Product refurbishment* : A process of returning a product to good working condition by **replacing or repairing** major components that are faulty or close to failure, and making 'cosmetic' changes to update the appearance of a product, such as cleaning, changing fabric, painting or refinishing. Any subsequent warranty is generally less than issued for a new or a remanufactured product, but the warranty is likely to cover the whole product (unlike repair).
   b. *Component remanufacturing:* A "process of disassembly and recovery at the subassembly or component level. Functioning, reusable parts are taken out of a used product and rebuilt into a new product.[21] In other words, remanufacturing means "restoring a non-functional, discarded or traded-in product to *like-new* condition. The key term in this definition is like-new. From the viewpoint of the producers this represents the manufacturers' intent, their claim for the product and their ability to live up to that claim."[22] The remanufacturing process "includes quality assurance and potential enhancements or changes to the components"[23].

iii. **Cascading of components and materials** Look for other, higher value uses for constituent material than material recycling of raw materials. It involves user-friendly, cost-effective, and quality-preserving collection

[19] The concept of 'technical nutrients' is specifically used in EMF report n°1 (2010) and n°2 (2012)

[20] *Towards the circular economy: Economic and business rationale for an accelerated transition*, EMF (2010)

[21] *Towards the circular economy: Economic and business rationale for an accelerated transition*, EMF (2010)

[22] Lund, R. T., *'Remanufacturing: An American Resource'*, in *Proceedings of the Fifth International Congress on Environmentally Conscious Design and Manufacturing*, Rochester, NY, 1998 p. 1

[23] *Towards the circular economy: Economic and business rationale for an accelerated transition*, EMF (2010)

systems; as well as treatment/extraction technologies that optimise volume and quality. For instance, in the textile sector, clothing can become furniture and then insulation material. Cascading use keeps materials in circulation for a longer period of time.

iv. **Material recycling:** "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".[24] Ellen MacArthur Foundation reports distinguish:
    a. *Upcycling*: converting materials into new materials of higher quality and increased functionality.
    b. *Functional recycling*: recovering materials for the original purpose or for other purposes, excluding energy recovery.
    c. *Downcycling*: converting materials into new materials of lesser quality and reduced functionality.

A circular economy approach for technical nutrients focuses either on the life cycle of a product across its value chain, or on industrial symbiosis, i.e. it can be cross sector (e.g., by-products of a company become the raw material of another producer: waste is a resource).

Eleven of the fourteen studies analysed in-depth for this literature review provide case studies on initiatives which create closed loops for technical nutrients. These case studies have been analysed in part 0.

2. Circular Economy loops for biological nutrients

In addition to cascading and industrial symbiosis approaches as identified as possible for technical nutrients, the literature review shows that there are three further means to create a more circular economy in the field of biological nutrients:

i. **Extraction of biochemicals**: "applying biomass conversion processes and equipment to produce low-volume but high-value chemical products, or low-value high-volume liquid transport fuel—and thereby generating electricity and process heat fuels, power, and chemicals from biomass. In a 'biorefinery' such processes are combined to produce more than one product or type of energy".[25]

ii. **Composting**: "biological process during which naturally occurring microorganisms (e.g., bacteria and fungi), insects, snails, and earthworms, break down organic materials (such as leaves, grass clippings, garden debris, and certain food wastes) into a soil-like material called compost. Composting is a form of recycling, a natural way of returning biological

[24] General Definition for Recycling as in Directive 2008/98/EC

[25] *Towards the circular economy: Economic and business rationale for an accelerated transition*, EMF (2010)

nutrients to the soil."[26] It is used as non-toxic ingredients in agricultural fertilizers.

iii. **Anaerobic digestion**: "process in which microorganisms break down organic materials, such as food scraps, manure, and sewage sludge, in the absence of oxygen".[27] This process generates biogas (methane and carbon dioxide) and a solid residual. Biogas can be used as a source of energy similar to natural gas, while the solid residual can be applied on the land or composted and used as a soil amendment.

iv. **Cascading of components and materials** (see definition for technical nutrients) – e.g. for paper.

3. Energy recovery and landfilling

After options with cost and resource savings have been exhausted or can no longer be chosen by economic actors due to the quality degradation constrains, the final *loop* for products would consist of energy recovery. Energy recovery can be defined as a process in which "non-recyclable waste materials can be converted into useable heat, electricity or fuel"[28], through combustion, gasification, pyrolysis, anaerobic digestion, or landfill gas recovery.

Finally, landfilling (i.e. disposing of waste in a site used for the controlled deposit of solid waste, onto or into land[29]) is considered as the last end-of-life solution for non-recyclable waste. The Ellen MacArthur Foundation states that a circular economy would avoid it and "would try to extract the maximum value from used products and materials", because landfilling creates negative externalities such as "its impact on land use—including the societal burden associated with siting choices—and greenhouse gas emissions."[30] For its part, the 'e-Waste Academy', co-organized by the United Nations University and the Global e-Sustainability Initiative (GeSI), envisions historical landfills as a largely untapped resource for many strategic metals, which has the potential to become the "mines of the future" and thus grow to be part of the circular economy loop. Yet, as European member states get better and better in diverting recyclable waste from landfills, landfills should be reserved to unrecoverable materials.

The figure below, taken from the 2nd report of the Ellen MacArthur Foundation (2013), illustrates how technological and biological nutrient-based products or materials can cycle through the economic system. The project team has added to this figure the red arrows and the

[26] *Towards the circular economy: Economic and business rationale for an accelerated transition*, EMF (2010)

[27] *Towards the circular economy: Economic and business rationale for an accelerated transition*, EMF (2010)

[28] *Towards the circular economy: Economic and business rationale for an accelerated transition*, EMF (2010)

[29] Landfill definition of the Council directive 1999/31/EC

[30] *Towards the circular economy: Economic and business rationale for an accelerated transition*, EMF (2010)

comments in red, to show that some strategies such as industrial symbiosis can create circular economy “loops” among manufacturing companies, without necessarily involving end users of a product.

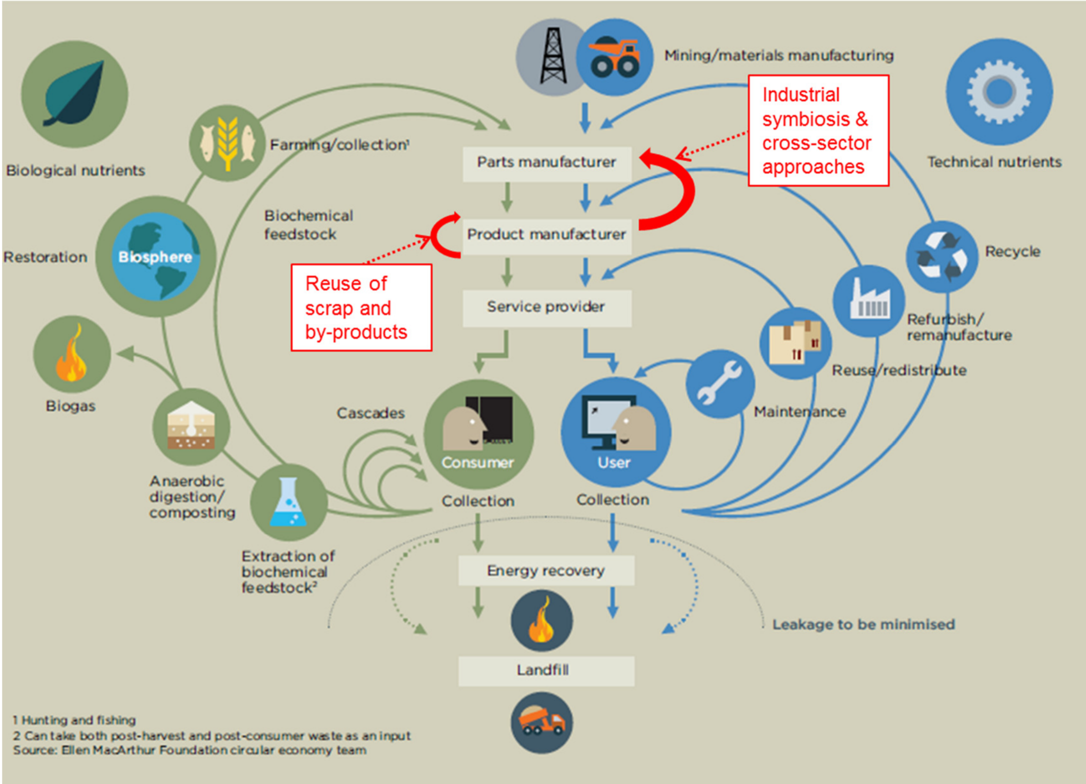

Figure 2 –Means that technological and biological nutrient-based products or materials can cycle through the economic system

IV. Barriers and drivers for a circular economy

To address part of the wider picture of the circular economy, a range of policies and measures are already in place in the EU: regulations (e.g. landfill bans, or product standards that embody design for durability, recovery and recycling), market-based instruments (e.g. taxes on consumption of non-renewable resources, for both materials and energies), information tools (e.g. labelling, certificates), principles (e.g. producer responsibility) and hierarchies (e.g. the waste hierarchy), voluntary approaches (e.g. CSR, reporting), trade rules, etc. Despite these efforts, there remains a range of opportunities to be realised, costs to be avoided, and a series of obstacles to address in order to go further and move towards a circular economy.

Most of the publications analysed in this literature review address the key drivers and barriers towards circular economy. These drivers, as well as the possible challenges and associated policy recommendations, are summarised in the table below.

Drivers and barriers have first been described and analysed for the **general framework conditions** necessary to move towards a circular economy, before being examined for each major stage of value chains/ supply chains :**Design and production; Consumption;** and **Recycling and recovery.** Lastly, as the transition to a circular economy has implications for logistics flows at all scales, drivers of a circular economy and associated barriers have been considered in the field of logistics. Logistical issues and solutions are cross-cutting, i.e. relevant at any stage of a value chain.

Whether drivers and obstacles are stemming from policy, regulation or the legal framework, or linked to social, cultural, economic, technological or infrastructural contexts, there is rarely only one driver in one sector or value chain. Typically several factors are in play and often the factors influence each other. For instance, an infrastructure to support the efficient collection of products after use ("reverse cycles"[31]or "reverse logistics", i.e. "a process of moving goods from their typical final destination for the purpose of capturing value, or proper disposal".[32]), which is an essential component for a circular economy, can be heavily influenced by various levers: policy instruments (such as landfill tax), extended producer responsibility (EPR), new business models and take-back schemes. The list of examples below is non-exhaustive but primarily targets policy-oriented drivers. The recommendations and other data are as described in the literature and they concern all levels of policy (European, national, and regional levels).

[31] *Towards the circular economy: Economic and business rationale for an accelerated transition*, EMF (2010)

[32] Hawks, Karen. "*What is Reverse Logistics*?", Reverse Logistics Magazine, Winter/Spring 2006.

Type of lever	Description of the lever and of their importance for circular economy	Associated challenges or barriers	Policy recommendations
General framework conditions	It seems necessary to move to valuation methods that **take into account the economic value of environmental externalities** (damages avoided or caused).[33] Three ways to promote circular economy by making the true cost of many of our resources visible are : - Economic incentives (internalisation of	• A barrier is the lack of internalisation of externalities[34] and the lack of resource pricing (cost recovery and pricing for the resource itself) which lead to economic signals that do not encourage a transition to a circular economy • The challenge is to get the prices right, i.e. to m**ake the true cost of resources apparent** in prices: proper evaluation of environmental externalities requires the correct understanding of environmental cost (not only the cost of compliance with	• **Regulations and choice restrictions** (such as the transition from incandescent light bulbs to energy-efficient lighting alternatives) can be used as **a partial means of appreciating externalities** so that circular economy based approaches can compete on a more even footing.[35] - **Extended Producer Responsibility (EPR) policies** are a way to internalise waste negative impacts. In the field of waste management, EPR is a strategy promoting the integration of environmental costs associated with goods throughout their life cycles into the market price of the products. It makes the manufacturer of a product responsible for the entire life-cycle of the product and especially for the take-back, recycling and final disposal. EPR policies have the advantage to incentivize producers

[33] Various sources among which the Aldersgate Group (2011) and the IAU (2013) studies

[34] Internalisation of externalities: incorporation of an externality into a market decision through pricing or regulatory interventions. For instance, internalisation can be achieved by charging polluters with the damage costs of the pollution generated by them, in accordance with the polluter pays principle. *[Source: European Conference of Ministers of Transport. Social costs glossary. CEMT/CS (97) 12.]*

[35] Example: a carpet manufacturer's circular economy based product competes against 'one use' manufacturing processes coupled with low cost landfill disposal for the end of life product. In EU countries where landfill disposal of carpet is prohibited, the circular economy product is increasing in market share. See *Resilience in the Round: Seizing the growth opportunities of a circular economy*, Aldersgate Group (2011)

	externalities); - Tax measures strong enough to change business behaviour - Subsidies to support virtuous and eco-friendly behaviours.	existing regulations and standards), choice of valuation technique, setting the time horizon, assessing distributional impacts and issues at different points in time, and evaluating risk, uncertainty, and ethical considerations. • Challenges regarding the **implementation of economic incentives and fiscal measures** supporting the development of a circular economy: - Administrative costs and monitoring of fiscal measures; - Lack of enforcement of legislation; Resistance to change – tax breaks require active decision by lawmakers to eliminate them; - Some incentives are perverse (incinerators that are too cheap;	to design more sustainable, less toxic, and easily recyclable products. • **Fiscal measures** - **Fiscal incentives** for individuals and companies to put materials back into circulation can help the transition to a circular economy – e.g. land-value taxes, value-extracted taxes, product levy and 'recovery rewards'. Example of a possibly impactful product levy: the phosphate levy.[36] - **Resource taxes** – tax base is the physical amount of the resource extracted – e.g. Aggregates Tax, (implemented in 16 European countries and reduced sales of virgin aggregates by 18m tons); Mineral Oil Tax (implemented in almost all European countries); Peat (Latvia, Lithuania, Sweden).[37] - **Removal of distorting subsidies** on resources, energy and land.[38] • **Subsidy schemes** - Enable businesses that use environmentally-friendly resources to write off a random percentage of the costs of

[36] Phosphate fertiliser underpins modern agriculture, and there is no substitute. Agriculture currently depends on ready access to phosphate rock, while considerable losses of phosphorus, between farm and plate, are not being addressed and while secondary sources of phosphate (in manure, human sewage, food and crop residues) are treated as wastes rather than as valuable nutrient resources. Green Alliance recommends the examination of a phosphate levy to raise money for phosphate recovery and recycling.
Source: Hislop. H. and Hill, J. (2011), *Reinventing the Wheel: A Circular Economy for Resource Security* (Green Alliance).

[37] *Economic Analysis of Resource Efficiency Policies,* COWI (2011)

[38] *A Global Redesign : Shaping the Circular Economy,* Chatham House (2012)

		taxes only levied on fossil fuels, but not on products based on fossil raw materials; subsidies, etc.). - Barrier to Extended Producer Responsibility policies: critics are concerned that manufacturers may use take-back programs to take second-hand valuable products (e.g., electronics) off the reuse market, by shredding rather than reusing or repairing goods that come in for recycling.	their business resources for a random year (e.g., The Random Depreciation of Environmental Investments, VAMIL, in the Netherlands). In the United States companies producing liquid biofuels receive direct subsidies for every gallon of ethanol produced.
Design and production	**Improving material selection, product design** (standardisation/modularisation of components, purer material flows, and design for easier disassembly) and **changing production methods** are levers for a circular economy.[39]	**Lack of skills in circular product design and production** • Lack of practice and infrastructure for the segregating of biological from technical nutrients and phasing out toxic materials are under-used and are therefore a priority.[40] • Knowledge development for the design process will have to focus on the art of combining constantly evolving standardization with designs that still allow manufacturers to	• **Investment and support programmes in eco-design and eco-innovation** - Support the investment in key technologies, e.g. in 3D printing and determine which components are most suitable for it. - Avoid using combinations of materials and include reusable parts in the design of products – e.g. Framework Programme Renewable Resources (Germany, € 800m fund), Resource Efficiency Science Programme (UK), piloting resource efficiency elements in under EU Ecodesign. - Governments could encourage the foundation of an extensive raw materials information service and increase

[39] *Towards the circular economy: Opportunities for the Consumer Goods Sector*, EMF (2012)
[40] *Towards the circular economy: Opportunities for the Consumer Goods Sector*, EMF (2012)

		distinguish themselves from their competitors.[41] • A substituted product does not necessarily help to reduce pressure on the environment but leads to increases in energy consumption e.g. plasma display panels. • Risk-averse behaviour by local governments regarding innovation (e.g., long wait for licences for technologies unfamiliar to new or low level local government officials). • Lack of dissemination about best practices – e.g. **SMEs** and sole traders have difficulties to keep up to speed with what is required due to a lack of funds for dissemination • Lack of information about green suppliers • Over communication, e.g. mail shots • Need a champion, i.e. individuals/ businesses who can promote resource efficiency[42]	the dissemination of knowledge about the development of new materials [43] • **Promoting cleaner production methods in SMEs** (metal processing, metal finishing, and food processing industries[44]) by offering a **production-integrated environment protection tool** where the relevant material flows and current level of production technology are analysed, and where recommendations are made. Example: EFA PIUS-Check initiative: the North Rhine-Westphalia (NRW) Ministry developed a toolbox to help SMEs improve their resource efficiency through avoiding pollution and improving re-source conservation in the production process. Scaling up the results of the PIUS policy pursued in the NRW to all SMEs in EU27 would create a potential economic benefit of EUR 776 million.[45] • **Support programmes** for existing local initiatives and networks – e.g. Resource Efficiency Clubs (UK) which provide opportunities for SMEs to engage in a range of activities, such as workshops, networking, best practice exchange, expert lectures, local projects, online forums and joint procurement.[46] • **Information Networks** – e.g. Environmental Sustainability

41 *Opportunities for a circular economy in the Netherlands*, TNO (2013)
42 *Business Resource Efficiency*, AEA (2009)
43 *Opportunities for a circular economy in the Netherlands*, TNO (2013)
44 The PIUS-Check initiative has been particularly successful in introducing cleaner pro-duction methods in the metal processing, the metal finishing and the food processing industries. For more details see *Economic Analysis of Resource Efficiency Policies*, COWI (2011)
45 *Economic Analysis of Resource Efficiency Policies,* COWI (2011)

			Knowledge Transfer Network (UK), Envirowise website (UK), Green Suppliers Network (US), Green Purchasing Network (Japan),[47] TUV (certifier of products in Germany). • Local advertising and awareness raising campaigns especially via radio • **Free (to business) advice and networking program at a regional level** to identify resource exchanges between companies for sustainable resource management solutions Example: National Industrial Symbiosis Programme (NISP) is a national programme, applied at a regional level across the UK. Each of the UK regions has a team of 'Industrial Symbiosis Practitioners' working closely with businesses in their area to recruit members to the programme and help them form symbiotic relationships with each other. As of May 2010, membership of NISP exceeded 13,400 companies of all sizes, and 40% of these have actively been involved in at least one synergy project. All NISP facilitation costs are covered by government; hence the members do not pay any fees. The potential cost saving of NISP at UK level is EUR million 187, and at the EU level it is EUR million 1 411.[48]
	Rethinking supply chains by taking industrial symbiosis possibilities into account, i.e. developing a good knowledge	**Lack of enablers to improve cross-cycle and cross-sector performance** • Many businesses are unaware of the	• The absence of a cultural context for inter-firm trust and collaboration can be mitigated through institutional mechanisms such as brokers or planning agencies, whose role is more than a waste exchange. Where typical waste exchanges

[46] Resource Efficiency Clubs (RECs) enable businesses to work with each other in their area to reduce their resource consumption and waste production, as well as increase their energy efficiency, overall environmental performance and sustainability. See business success stories here.

[47] *Economic Analysis of Resource Efficiency Policies,* COWI (2011)

[48] *Economic Analysis of Resource Efficiency Policies,* COWI (2011)

	of the energy and material flows of an industrial sector or geographical area so as to optimize their use and see where they can be improved	exact origin or the composition of the raw materials they use. • Symbiosis requires exchange of information about nearby industries and their inputs and outputs that is often difficult or costly to obtain. In the Kalundborg model (*see Figure 1 in part* A), the city's small size of about 12,000 residents and its relative isolation have created a tight-knit community in which employees and managers interact socially with their counterparts on a regular basis. If, in Kalundborg, no deliberate institutional mechanism was needed to promote inter-firm trust, elsewhere, especially where there is a strong tradition of company privacy, such natural communication is much more difficult to find.[49]	merely list available by-products, such planning agencies would perform every function required to turn a by-product into a feedstock, including finding appropriate uses, dealing with regulatory agencies, brokering necessary agreements, and even transporting the materials from the generator to the user.[50] • As in Denmark (see description of Kalundborg industrial symbiosis in in Figure 1), the regulatory system would benefit from being be consultative, open, and flexible: instead of being put on the defensive (characteristic of a command-and-control framework), firms, in Denmark, are required to be proactive by submitting plans to the overseeing county government detailing their efforts to continually reduce their environmental impact. A key aspect of the flexibility required here is that **regulatory requirements are mainly in the form of performance standards stating the degree of the desired decrease**, instead of technology standards as is common in the United States. Indeed, technology standards assure that uniformly effective pollution-control methods are adopted throughout a given industry but tend to hinder technological or infrastructural innovation. Yet, there are disadvantages to the Kalundborg system (see description of Kalundborg industrial symbiosis in in part **Error! Reference source not found.**): potentially lower levels of technical compliance and high transaction costs incurred in extensive consultations around permitting.

[49] *"Industrial Ecology in Practice – The Evolution of Interdependence at Kalundborg",* J. Ehrenfeld and N. Gertler (1997), Journal of Industrial Ecology
[50] *"Industrial Ecology in Practice – The Evolution of Interdependence at Kalundborg",* J. Ehrenfeld and N. Gertler (1997), Journal of Industrial Ecology

			Although U.S. technology standards are inflexible, they ensure a certain minimum level of pollution control.[51]
Consumption	• The move from product to service for consumers (consumer-as-user)[52] is instrumental in translating products designed for reuse into attractive value propositions. • The 'peer-to-peer' economy' (e.g. for transportation and housing, like Lyft and Airbnb) also enables access to products and services instead of ownership. • Repair and reuse is key to create economic loops • Improving consumer knowledge on origins and perishability and incentivising consumers to generate less waste is key	• Changing from ownership to usage and performance-based payment models and expanding the product definition to embed it in related services require good knowledge of value chain participants' needs and ongoing innovation. • While there has been a discernible societal shift towards access rather than ownership (e.g. carpool), consumer acceptance needs to grow significantly. In addition, there must be a realignment of cultural values and incentives – particularly in the sales functions of businesses (consumers tend to look more at the purchase price of a product and less at the entire lifecycle costs).[53] • Anti-trust concerns led firms to end pay-per-use schemes in the past (e.g. Xerox and IBM formerly rented their	• Support and promote innovative leasing and rental contracts to (pay-per-use instead of ownership) – e.g. Michelin pay-for-use tires for truck fleets. • Expand the product definition to embed it in related services (e.g., power tools combined with building kits and training).[55] • Encourage the 'peer economy' – e.g., LETS circles (local, non-profit swap networks where goods and services can be exchanged without the need for money)[56] • Encourage repairs through Internet services[57] – e.g. Lenovo (offers a tool for searching for spare parts on the Internet and provides manuals for repairs), Logitech (has an online parts store), or Fixya.com (an online community that provides people with tips and instructions to solve problems themselves). • Support initiatives promoting repair and reuse, such as: • The **creation of 'repair cafés'** (referenced at www.repaircafe.org, for any country where 'repair cafés' exist) where residents take their broken goods to repair them with the assistance of experts. • The iFixit website (www.ifixit.com), an interesting pilot project: it is a global community of people helping each other

[51] *"Industrial Ecology in Practice – The Evolution of Interdependence at Kalundborg"*, J. Ehrenfeld and N. Gertler (1997), Journal of Industrial Ecology
[52] *Dutch Logistics 2040, Designed to last* , Council for the Environment and Infrastructure study (2013)
[53] *Resilience in the Round: Seizing the growth opportunities of a circular economy*, Aldersgate Group (2011)

	to build a circular economy • Waste separation at source is key • Public institutions are also consumers: sustainable procurement measures for public authorities should be taken into account in designing a more circular economy	machines). Users can become dependent on the producers, because of long-term contracts for example.[54] • Risk of "cannibalisation": there will be a number of winners and losers in the shift to a circular economy. As new business models develop and there is a shift from ownership to services, the result will be various 'cannibalisation rates' where certain businesses lose market share to innovators. Vested interests will seek to maintain the status quo and be resistant to change. • Lack of information on product perishability: there is confusion between 'Best before' (BB) and 'Use by' (UB) labels • Lack of standardization of methodologies applied in different countries for labelling products:, the cost of assessing resource consumption for individual firms, and	repair things (online advice and video), and iFixit has its own online shop of repair tools and replacement parts (for all popular gadgets, from iPhone batteries to MacBook displays) • Develop consumer knowledge on perishability of products (e.g. GS1 DataBar, informational barcode about the shelf life of a product). • Develop consumer knowledge on origins: a certification or labelling system for circular economy products would help to build awareness among consumers, encourage rapid uptake by companies and reward leading companies by allowing them to capture a green premium. • Develop incentives such as. PAYT (Pay as you throw) or DIFTAR, a system of differentiated tariffs where citizens are charged according to the amount and type of waste they generate • Waste separation at source: separate food waste collections to become widespread for households and businesses • Municipalities can develop mobile phone apps to inform citizens about waste collection points and 'repair shops'. • The circular economy concepts could be fostered in university curricula (e.g. fellowship program of the Ellen MacArthur Foundation, aimed at fostering aimed at fostering the circular

[55] *Towards the circular economy: Opportunities for the Consumer Goods Sector*, EMF (2012)

[56] "LETS circles use tax-free, local forms of credit, so people do not have to trade over there directly. A member of a LETS circle can for example earn credit looking after the child of one member and later spend it on a carpentry service performed by another member in the same LETS circle. The local LETS circle centrally registers credit earned and spent and this credit is visible to all members of the LETS circle. The members also determine the amount of credit necessary for specific c goods and services." (LETS, 2011 and Wikipedia, 2013b)

[57] *Dutch Logistics 2040, Designed to last* , Council for the Environment and Infrastructure study (2013)

[54] *Opportunities for a circular economy in the Netherlands*, TNO (2013)

		the absence of a widely recognized, independent organization to award certification on resource efficiency or circular economy criteria. • Lack of incentives preventing households from generating waste • Lack of **education** on the opportunities and drivers of circular economy	economy issues which encompass participation of Imperial College London, London Business School and Cranfield University)[58]. • Public procurement**:** obligations for public-sector agencies and government departments to purchase resource-efficient and cradle-to-cradle products. In many countries this is a powerful lever for creating markets for more sustainable goods and encouraging innovation.[59]
Recycling and recovery	The development of recycling and recovery infrastructure, processes and technology is a important feature to support a circular economy.	• Over the last decade consumer products have become considerably more complex, making effective and efficient recovery a massive challenge. • Future market developments are highly uncertain so investing in large-scale recycling is perceived as very risky. • Although reduction in the use of raw materials is positive, in the case of some products, economically viable recycling is no longer possible and has led to the suboptimal reuse of materials • Availability of products components	• There may be a role for Government to stimulate recycling and recovery through investment support in regional infrastructure and for companies seeking to develop in this market. [60] • Set up Business parks, Business Improvement Districts and other **clusters of SMEs to facilitate collective long term contracts for recyclable waste collections.** This will make it cheaper to invest in collection and recycling infrastructure.[61] • The end-of-waste criteria allow precious natural resources to come back into the economy by facilitating and promoting the recycling in the EU. Legal clarity of regulations is therefore needed and can be achieved by harmonising quality criteria across the whole of the EU. Furthermore, progress remains to be made regarding the status of a 'by-product' or the concept of 'reuse', to comply with the waste management hierarchy,

[58] http://www.ellenmacarthurfoundation.org/education/schmidt
[59] *A Global Redesign : Shaping the Circular Economy*, Chatham House (2012)
[60] *Towards the circular economy: Opportunities for the Consumer Goods Sector*, EMF (2012)
[61] *Going for Growth: A practical route to a Circular Economy*, ESA UK (2013)

		for repair by independent operators is often blocked by businesses that have a monopoly on supplies of components or products.	which emphasizes reuse before recycling. The legal status of by-products should help promote direct eco-industrial synergies in so far as by-products defined as such remain non-waste.[62] • Removal of a number of regulatory obstacles to the use of biotic waste streams could make it easier to use them as bio-based. Example: "An amendment to Dutch waste regulations (Dutch Environmental Management Act, chapter 10), which came into effect in March 2011, has meant that some agricultural and forestry waste streams are no longer regarded as waste products, so that the waste regulations no longer apply. The amendment originates from the European Waste Framework Directive and has removed many obstacles, although there are conditions. Materials such as crop residues and wood shavings must be used for agricultural or forestry purposes, or to generate energy, and they must not be harmful to humans or the environment."[63] • Develop knowledge for biotic waste to be reused and transformed through biorefining (potatoes, maize, straw, potato haulm, draff, sugar beet) • Incentivize suppliers and retailers to assume mandatory take-backs if a product remains unsold (magazines, bread, etc.)

[62] *Évolution du statut de déchet : une contribution à l'économie circulaire ?*, Droit de l'Environnement n°128 *(2013)*
[63] *Opportunities for a circular economy in the Netherlands*, TNO (2013)

Logistics	The transition to the circular economy has implications for logistics flows at global, national and local levels. Logistics is primarily a matter of organising, planning, managing and handling cargo flows, from purchasing via production and distribution to the end user, including return flows and supply chain management in general. At the global level, the more control companies wish to exercise over the full lifecycle of a product, the more attractive it becomes to operate close to the customer (near-sourcing). At the national level, the transit functions will change. At the local level, an increase in transport movements will occur due to the increase in near-sourcing and e-commerce, but also to an increase in service logistics and reverse logistics.	• Each city develops its own transport flows system, which leads to confusion among shippers and transporters. Policies between municipalities for transport need to be harmonized (loading times, weights and measures, etc.) • Network design and management need to be improved and better interconnected so as to switch to a different mode of transport in the case of disruptions.[64]	• Streamline transport flows and urban distribution : - Business-to-business concepts such as Green City Distribution, Binnenstadservice, Cargohopper (in the Netherlands); - Business-to-consumer concepts such as DHL; - System solutions (partnership between retailers on the same street or by sector/product; cooperation between transport companies). Digitisation is one of the tools available to shape partnerships.[65] • Municipalities could invite shippers to develop concepts for city logistics through innovative (i.e. flexible and incentivising) tendering and supply chain-transcending cooperation. Tenders would formulate clear end goals, including noise and air emissions, maximum number of transport movements, and load factor for both inbound and outbound flows, service logistics, and involvement of all stakeholders.

[64] Term used in logistics to refer to the transport of people and goods across the last metres to the final destination.
[65] *Dutch Logistics 2040, Designed to last* , Council for the Environment and Infrastructure study (2013)

Conclusions

What currently drives the circular economy is what maximizes value along the value chain and, importantly, what enables the assets to be continually re-introduced to markets. Once a material is seen as an investment and customers as users, it makes business-sense to maintain the customer relationship during multiple cycles. The policies which enable business models and value chains to be more circular, in every sector and along any value chain, are the ones which:

- Encourage manufacturers to design products with asset recovery in mind and to take into account the true cost of materials;
- Encourage the development of product lines that meet demand without wasting assets;
- Incentivise businesses to source material from within regenerative loops, rather than from linear flows;
- Enable businesses to develop a revenue model that generates value at all parts of the value chain; and
- Get customers/ consumers to change their consumption and ownership patterns.

This literature review has identified the following gaps which currently act as barriers to the development of a circular economy, and therefore where further consideration of policy action may be beneficial in promoting the circular economy:

- the lack of internalisation of externalities and the lack of resource pricing (cost recovery and pricing for the resource itself), which lead to economic signals that do not encourage a transition to a circular economy;
- the lack of skills and investment in circular product design and production;
- the lack of enablers to improve cross-cycle and cross-sector performance;
- the lack of consumer and business acceptance regarding consumer-as user, and performance-based payment models;
- the lack of know-how and economic incentives regarding repair and reuse;
- the lack of consumer information on origins and perishability of products (information on origins of products might for instance drive people to buy local products or products made out of recycled materials);
- the lack of waste separation at source (especially for food waste and packaging);
- the lack of sustainable procurement incentives for public authorities;
- the lack of investment and innovation in recycling and recovery infrastructure and technologies;
- the lack of harmonisation of transport flows systems between municipalities, which leads to confusion among shippers and transporters.

This list is non-exhaustive but covers the main barriers to the development of a circular economy.

From a policy standpoint, addressing these barriers means:

- Encouraging economic players to take into account the economic value of their environmental externalities through:

- Regulatory requirements such as the ones posed by the Extended Producer Responsibility (EPR) principle. EPR promotes the integration of environmental costs associated with goods throughout their life cycles into the market price of the products, and, thanks to financial incentives, encourages manufacturers to design eco-friendly products by holding producers responsible for the costs of managing their products at end of life. This policy approach differs from Product stewardship (where responsibility is shared across the value chain of a product), and attempts to relieve local governments of the costs of managing certain priority products by requiring manufacturers to internalize the recycling cost within the product price.
- Economic incentives to encourage the recovery of more secondary raw materials, such as the phosphate levy which fosters the recovery of phosphate from sewage and the use of high quality, secondary sources of phosphate in agriculture.
- Tax measures and subsidies strong enough to change business behaviour (see examples in the table above).

- Encouraging the development of skills, curricula (for students and professionals), awareness and investment in circular product design and production, as well enabling to improve cross-cycle and cross-sector performance, through:
  - Support programmes for businesses investing in eco-innovation (technological and non-technological innovation). Example: the Competitiveness and Innovation Framework Programme (CIP) which aims to encourage the competitiveness of European small and medium-sized enterprises, in particular in the field of eco-innovation. The CIP provides access to finance and delivers business support services in the regions.[66]
  - Support programmes for companies that avoid using combinations of materials and include reusable parts in the design of products (eco-design) – e.g. Framework Programme Renewable Resources (Germany, € 800m fund).
  - The development of an extensive raw materials information service and increase the dissemination of knowledge about the development of new materials.
  - The promotion of cleaner production methods in SMEs by offering a production-integrated environment protection tool where the relevant material flows and current level of production technology are analysed, and where recommendations are made.
- Encouraging the improvement of cross-cycle and cross-sector performance, through:
  - The development of free-to-business advice and networking program at a regional level to identify resource exchanges between companies for sustainable resource management solutions – e.g. National Industrial Symbiosis Programme (NISP) (UK).
  - The development of local networking for industrial symbiosis opportunities, perhaps via an internet application.
  - The availability of planning agencies who would perform, in a given territory and for the industries of this territory, every function required to turn the industries' by-products into feedstocks, including finding appropriate uses, dealing with regulatory agencies, brokering necessary agreements, and even transporting the materials from the waste/ by-product generator to the user.
- Encouraging the change in consumption patterns through:
  - The support and promotion of innovative leasing and rental contracts (pay-per-use instead of ownership). When goods vendors embrace the idea of themselves as service

[66] See http://ec.europa.eu/environment/ecoap/about-action-plan/community-funding-programmes/index_en.htm

providers, this can lead not only to an effective hedge against cost volatility but also strengthens the customer relationship and increases the upsell, such as in Vodafone's Red-Hot plan[67] (customers can rent the latest phone for a year and keep on exchanging it for a newer version; while Vodafone is engaged in collecting the old phone, which enables material collection and pooling and creates deeper customer relationships).
  - The support and protection of the 'peer economy' (collaborative consumption) and of initiatives promoting repair and reuse, such as the creation of 'repair cafés' (see table below for further detail).
  - The development of consumer knowledge/ awareness on perishability of products (e.g. GS1 DataBar, informational barcode about the shelf life of a product) and on origins of products (certification, labelling).
  - The development of incentives such as. PAYT (Pay as you throw) or DIFTAR, a system of differentiated tariffs where citizens are charged according to the amount and type of waste they generate.
  - The set-up of a regulation to separate food and packaging waste at source.
  - The development of obligations for public-sector agencies and government departments to purchase resource-efficient and cradle-to-cradle products.
- Encouraging the investment and innovation in recycling and recovery infrastructure and technologies through:
  - Investment support in regional infrastructure and for companies seeking to develop innovative recycling and recovery technologies (e.g. Starbucks actually aims to turn thousands of tons of its waste coffee grounds and food into everyday products by using bacteria to generate succinic acid which can then be used in products such as detergents, bio-plastics and medicines[68]).
  - The set-up of Business parks, Business Improvement Districts and other clusters of SMEs to facilitate collective long term contracts for recyclable waste collections. This will make it cheaper to invest in collection and recycling infrastructure.
  - The harmonisation of the quality criteria of the end-of-waste status across the whole of the EU. Furthermore, progress remains to be made regarding the status of a 'by-product' or the concept of 'reuse', to comply with the waste management hierarchy, which emphasizes reuse before recycling.
  - The removal of a number of regulatory obstacles to the use of biotic waste streams, such as in the Dutch Environmental Management Act (chapter 10).
  - The development of knowledge for biotic waste to be reused and transformed through biorefining (potatoes, maize, straw, potato haulm, draff, sugar beet).
  - Incentives for suppliers and retailers to establish mandatory take-back arrangements if a product remains unsold (magazines, bread, etc.)
- Encouraging the harmonisation of transport flows systems between municipalities, which leads to confusion among shippers and transporters (see examples on the table above).

Part 0 below outlines pre-existing prioritization of value chains, material flows, sectors and products from a circular economy perspective, and weighs the proven or potential environmental and economic impacts associated with circular initiatives in such sectors.

[67] See Vodafone website.
[68] See Starbucks website

V. Impacts and priority value chains, material flows and sectors/ products

A. Global impacts

As the Ellen MacArthur Foundation report shows, benefits of implementing a circular economy include: material savings, mitigation of price volatility and supply risks, sectorial shifts towards a 'user-centric economy', possible employment benefits, and reduced externalities.[69] These specific benefits are estimated in the report as follows:

1) A transition to a circular economy would bring a **net material cost saving** opportunity of EUR 250 to 280 billion p.a. at EU level for a 'transition scenario' and EUR 380 to 460 billion p.a. for an 'advanced scenario'. 'The latter would equate to 19% to 23% of current total input costs or a recurrent 3% to 3.9% of 2010 EU GDP.'[70]

2) 'The resulting net material savings would result in a shift down the cost curve for various raw materials.' This shift would **reduce demand-driven volatility** by moving away from the steep side of the cost curve.[71]

3) Walter R. Stahel explains the mechanism behind the **creation of jobs** as a consequence of a transition to a circular economy:

- "Less than a quarter of the labour input to produce a physical good is engaged in the fabrication of basic raw materials such as cement, steel, glass and resins, while more than three quarter are in the manufacturing phase."
- "The reverse is true for energy inputs; three times as much energy is used to extract virgin or primary materials as is used to manufacture products from these materials.
- "Reused components and goods use less energy and material, provide more jobs and are cheaper than manufacturing new ones (the ratios "value-per-weight" and "labour input-per weight" are considerably higher)."[72]

4) 'As material and products are the carrier of the embedded externalities, a reduction in volumes will also lead to a **reduction in associated externalities**—higher than any incremental efficiency improvement in the existing material chain.'[73]

The impact of a transition to a circular economy has also been estimated in some Member States:

In the **UK**, it is estimated that a circular economy that increasingly re-uses and recycles the resources the country already has could help generate **50,000 new jobs** and **EUR 12 billion of investment**, boosting the **GDP by EUR 3.6 billion**. Furthermore, taking circular economy

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[69] Ellen MacArthur Foundation, Volume 1 (2010), p.10
[70] Ellen MacArthur Foundation, Volume 1 (2010), p.9
[71] Ellen MacArthur Foundation, Volume 1 (2010), p.10
[72] Walter R. Stahel, The drivers behind the shift from a linear to a circular economy, CES, 16.02.11, http://www.surrey.ac.uk/ces/news/seminars_events/archive/walter_stahel_Powerpoint.pdf
[73] Ellen MacArthur Foundation, report n°1 (2010), p.10

principles into account when designing products could allow for **140 million extra tons of potentially recyclable resources** to be successfully returned to the economy between now and 2020, leading to **EUR 1.7 billion** in extra recyclate revenues for the UK economy.[74]

For the Dutch economy, the circular economy could amount to **7.3 billion** a year in market values (or 1.4% of today's GDP) and could create **54,000 jobs**.[75]

It is important to note that transitioning to a circular economy would also have important non-economic benefits. The Netherlands, for instance, also estimates that adopting a circular economy would bring:

- A reduction of **17,150 kt in CO_2 emissions** (roughly Estonia's CO_2 emissions for the year 2010: 18,339 kt,[76] with a population of 1,339,396 people)[77]
- A reduction in land use of **2,180 km²** (approximately the size of Monaco)
- Avoided use of fresh water of **0.7 billion m³** (0.47% of EU-15 freshwater resources)[78]
- Avoided use of raw materials of **100,400 kt** (more than 25% of the total imports of goods by weight in the Netherlands/ year)[79]

However, as circularity increases, **there will be losers during the economic transition**: as more goods are reused and repaired, fewer new goods will be bought, which in turn means a loss of income for manufacturers, transporters and dealers. In the case studies mentioned below (section B), it was assumed that an increase in the number of products reused and repaired has a reciprocal effect on purchases of new products, that the reuse of components leads to a gradual decline in purchases (assumed by 75%) and that an increase in recycling does not affect purchases of new products.[80]

B. Priority sectors, products or materials

A number of reports on circular economy have sought to establish priority areas for circular economy policy because they have a particularly high potential for circularity and resource efficiency. Two approaches exist: establishing priority sectors/products or priority material flows. As such, they will be examined separately in the following section. These two methods can be linked however (cf. Table 1 in the Annexes) to establish priorities in more detail within a particular sector.

[74] Environmental Services Association (ESA) UK, Going for Growth: A practical route to a Circular Economy (2013)
[75] The Netherlands Organisation for Applied Scientific Research (TNO), Opportunities for a Circular Economy in the Netherlands (2013)
[76] The World Bank, http://data.worldbank.org/indicator/EN.ATM.CO2E.KT/countries, last accessed 13/02/2014
[77] The World Bank, http://data.worldbank.org/indicator/SP.POP.TOTL, last accessed 13/02/2014
[78] Eurostat, http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-NQ-03-003/EN/KS-NQ-03-003-EN.PDF, last accessed 13/02/2014
[79] The Netherlands Organisation for Applied Scientific Research (TNO), Opportunities for a Circular Economy in the Netherlands (2013)
[80] The Netherlands Organisation for Applied Scientific Research (TNO), Opportunities for a Circular Economy in the Netherlands (2013), p.26

The first approach by sector/product is the most pertinent within a circular economy context, as circular economy models are usually designed around products and services. Thus, the results of that approach will be examined first.

C. Priority sectors/products

In terms of priority sectors/goods, some have already been presented as a priority for policy in previous reports.

The Ellen MacArthur Foundation Report Volume 1 places an emphasis on **complex medium-lived products**, which represent 48.6% of the GDP contribution of the manufacturing sector within the EU economy and EUR 1.44 trillion in final sales in the EU-27. The sectors that produce these products are: **machinery** and equipment; office machinery and computers; **electrical machinery and apparatus**; radio, television, and communication equipment and apparatus; medical, precision and optical instruments, watches and clocks; motor **vehicles**, trailers, and semi-trailers; other transport equipment; and furniture and other **manufactured goods**.

The reason why they are presented as having a high potential is that they 'are in use for a short enough timeframe that they are subject to frequent technological innovation, but long enough that they are not subject to one-off consumption', they also contain multiple parts that can be disassembled and refurbished. Within these sectors, certain products are studied in detail by the report: mobile phones, smartphones, light commercial vehicles, washing machines and power tools.[81] For these products, an increase in circularity can be profitable at product level but could also have an important economic impact on the product market.[82]

For each of these products, the economic benefits of increased circularity are significant:

- **Mobile phones**: the cost of remanufacturing would decrease by 50% per device if they were easier to take apart and were returned by customers.[83] Furthermore, in a transition scenario with 50% of phones collected, European market-wide savings on manufacturing material costs could add up to more than USD 1 billion. In an advanced scenario with a 95% collection rate and an equal split between reuse and manufacturing, material and energy savings could amount to EUR 1.45 billion (USD 2 billion) on material and USD 160 million on energy per year (both net of material and energy used in the reverse- cycle process).[84] Policies to boost collection rate are essential for such changes to occur.
- **Smart phones**: in a transition scenario, the overall material input cost savings in B2B (business-to-business) could be of more than EUR 350 million per year while in an advanced scenario, they could be of EUR 400 million (USD 550 million).[85] Similarly to

[81] Ellen MacArthur Foundation, Report Volume 1 (2010), p.36-37
[82] Ellen MacArthur Foundation Report Volume 1 (2010), p.38
[83] Ellen MacArthur Foundation Report Volume 1 (2010), p.8
[84] Ellen MacArthur Foundation Report Volume 1 (2010), p.41
[85] Ellen MacArthur Foundation Report Volume 1 (2010), p.44

mobile phones, increasing the collection rate is crucial to increase the circularity of this product.

- **Light commercial vehicles**: Collection rates for these vehicles are already at 71% approximately but a shift in volumes from recycling to refurbishing could save material inputs by EUR 6.4 billion (USD 8.8 billion) per year (about 15% of the material budget). This would save EUR 140 million (USD 192 million) in energy costs and reduce greenhouse gas emission of the linear supply chain by 6.3 million tonnes.[86]
- **Washing machines**: A business model change from consumers as buyers to consumers as users would allow savings for the consumer and manufacturer as well as savings in terms of material and energy use. If high-quality washing machines with a 20 year-life span were leased for 5 years instead of being sold, they could be refurbished between users. 'Given similar material compositions and production processes, replacing five 2,000 cycle machines with one 10,000 cycle machine yields almost 180 kg of steel savings and more than 2.5 tonnes of CO_2e savings'.[87]
- **Power tools**: In a similar way to washing machines, these could move towards a consumers as user's model.[88]

The Ellen MacArthur Foundation Report Volume 2 states that **fast-moving consumer goods** (**food**, **beverages**, **textiles** and **packaging**) are a priority, as they are bought more often than other products whilst having a shorter service life. Indeed, they currently account for about 60% of total consumer spending, 35% of material inputs into the economy, and 75% of municipal waste.

Importantly, the consumer goods sector absorbs more than 90% of the world's agricultural output – possibly the most in-demand group of resources in the future.[89]

The value of improving the circularity of fast-moving consumer goods could be of EUR 509 billion (USD 700 billion) per annum in material savings. 'Those material savings would represent about 20% of the materials input costs incurred by the consumer goods industry.'[90]

The report emphasises the importance of building efficient collection systems to capture the materials value of consumer goods.[91]

The Ellen MacArthur Foundation has assessed the "potential for circularity" of various products, illustrated in Figure 3. The matrix shows the potential for these sectors to adopt a circular business model; and therefore capture value through these business models. Other products with similar characteristics would also bring business opportunities if their circularity was increased.

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[86] Ellen MacArthur Foundation Report Volume 1 (2010), p.45-46
[87] Ellen MacArthur Foundation Report Volume 1 (2010), p.47
[88] Ellen MacArthur Foundation Report Volume 1 (2010), p.50
[89] Ellen MacArthur Foundation, Report Volume 2 (2012), p.5
[90] Ellen MacArthur Foundation, Report Volume 2 (2012), p.9
[91] Ellen MacArthur Foundation, Report Volume 2 (2012), p.7-8

The activities with a high circularity potential are in the top left quadrant: shampoos, hospital beds, furniture, light commercial vehicles, washing machines but also business lines that have already started going in that direction, such as construction equipment, heavy machinery and aeronautics.

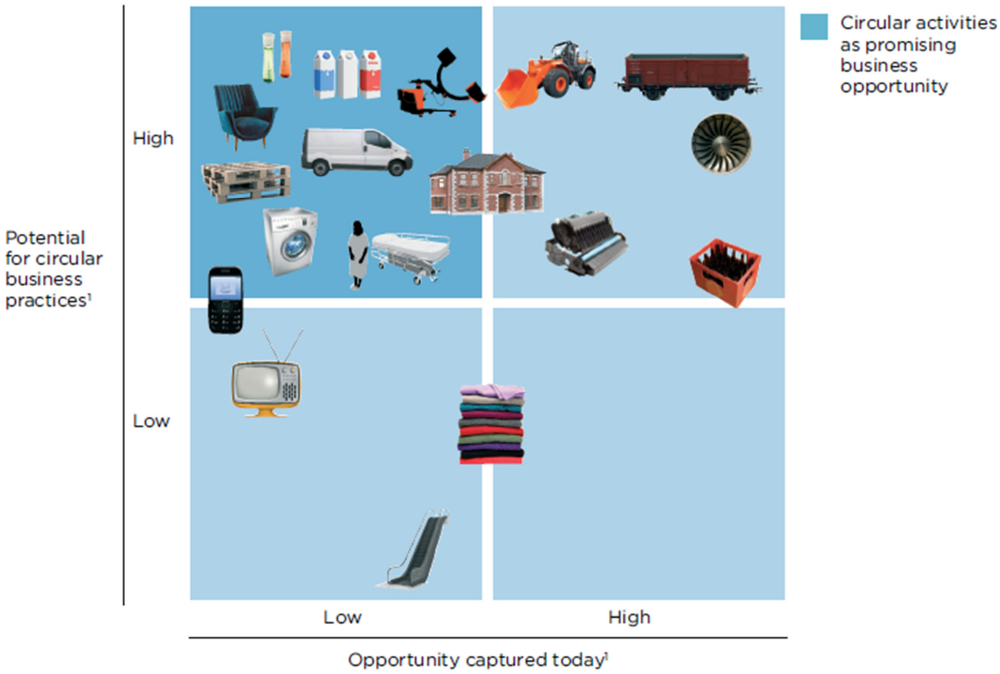

Figure 3: Potential for circularity of various products within the economy

Increasing circular activities is a promising business opportunity for a variety of products[92]. The "potential for circularity" is measured in terms of product design, reverse logistics (e.g., developed remanufacturing activities) and likelihood of developing circular activities; and by the ease of implementing these, which is driven by customer acceptance of such practices/ products, and convenience/incentive to return goods.[93]

- Improving circularity through product design includes standardisation, modularisation, non-toxicity of the components, design for easier disassembly, etc.
- Reverse logistics is concerned with the efficient reuse products and materials, from the consumption phase (their typical final destination) to the recapturing of value or proper disposal.[94]
- As for the "opportunity captured today", it is driven by reuse, refurbishing, remanufacturing and recycling activities in respective markets (positioning has been validated by experts).

A 2011 EU Commission report on resource efficiency policies establishes that priority sectors include specifically, the **construction** and **food** sectors and in a second phase, **electronics**, **automotive** and **agriculture** sectors. This is because they represent more than 50% of Total

[92] Ellen MacArthur Foundation, Report Volume 1 (2010), p.65
[93] Ellen MacArthur Foundation, Report Volume 1 (2010)
[94] Hawks, Karen, What is Reverse Logistics?, *Reverse Logistics Magazine*, Winter/Spring 2006, http://www.rlmagazine.com/edition01p12.php, last accessed 14/02/2014

Material Requirements (TMR) and have high savings potential - up to 20% for some of them.[95] These sectors can be refined to key resources used by them to identify policies for resource efficiency[96]:

- Agriculture: water; soil/land; fertilisers (phosphorus)
- Electronics: steel; copper; aluminium; rare earth metals
- Construction: aggregates and limestone; wood
- Automotive: steel; aluminium; plastics
- Food sector: meat; milk; the potential lies in improving handling and transport to limit waste.[97]

The report estimates EU-wide economic savings based on case studies for each one of these sectors.

- For **agriculture**, the report gives the example of an Australian government water programme, where 'EUR 2.1 billion has been allocated by the Australian government with the aim of purchasing water entitlements which represent the rights of land owners to receive a share of the consumptive pool within an area' to increase water efficiency and the farmers' flexibility to respond to water needs changes. About 766 million $m^3$of water could be purchased. This system could be used in southern Europe with a water saving potential for Bulgaria, Greece, Spain and Romania is estimated to around 6,600 million m^3 annually.[98]
- For **construction**, the economic savings of expanding the UK aggregate levy for the environmental impacts of the extraction and transportation of construction materials (including noise, dust, vibrations, visual intrusion, loss of biodiversity, etc) would be of EUR 1.7 billion for the private sector and EUR 2.1 billion for the public sector.
- For the **automotive** sector, the Green Supplier Network in the US is shown as an example of a programme run jointly by the government and the industry to improve companies' manufacturing methods. The programme was not limited to the automotive sector and included aerospace, healthcare and office furniture. Annual savings for each company were of EUR 86,700.[99]

The Netherlands Organisation for Applied Scientific Research (TNO)'s report on opportunities for circularity in the Netherlands specifically emphasizes **electrical products**, and bases its results on Ellen MacArthur Foundation reports.[100]

The Council for the Environment and Infrastructure of the Netherlands's report[101] mentions the **high-tech**, **agriculture** and **food** sectors as areas that can tackle the 'discrepancy' between lack of resource and increase in consumption.

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[95] COWI, Economic Analysis of Resource Efficiency Policies (2011), p.55
[96] COWI, Economic Analysis of Resource Efficiency Policies (2011), p.38
[97] COWI, Economic Analysis of Resource Efficiency Policies (2011), p.53
[98] COWI, Economic Analysis of Resource Efficiency Policies (2011), p.79-80
[99] COWI, Economic Analysis of Resource Efficiency Policies (2011), p.76
[100] TNO, Opportunities for a Circular Economy in the Netherlands (2013), p.13-14

In terms of policies, the report recommends moving from a 'product' to 'service' model for the **high-tech** sector because of its use of scarce resources.[102]

For the **agriculture** and **food** sectors, the priority they establish is to 'move from retail to consumers as pivot in the chain'.[103] It is important to understand the underlying demand for food services as food will increasingly be delivered to him directly. Thus, direct sourcing and taking into account consumer preferences are key to limit food and energy waste.

All these reports agree that the following sectors are priority areas for the development of a circular economy: **construction, food, electrical products and electronics and secondly, agriculture and vehicles.**

Below is a table illustrates policies and existing initiatives to increase resource efficiency and circularity.

Table 1: Initiatives to increase the circularity of certain products/sectors

Sector	Actors	Initiative	Proven or potential Impact
Construction and demolition sector	Kajima Construction Corporation[104]	The Japanese government has supported deconstruction through legislation and policies.	In Japan, Kajima Construction Corporation developed a new deconstruction technique that allowed it to recycle 99% of the steel and concrete and 92% from a building.
Construction	Caterpillar[105]	For the past 30 years, they have developed remanufacturing for a range of industrial products from earth-moving machines to water pumps	59,000 tonnes of steel, 91 metric tonnes of cardboard and over 1,500 tonnes of wood products were saved in 2010 and end-of-life parts have a return rate of over 90%
Construction	UK government[106]	Centralized ad quantum-tax by weight to address environmental impacts of extraction and transportation of construction materials to encourage the more efficient use of aggregates	EUR 5,682.6 million in potential revenue at an EU scale (for EUR 2/ton)

[101] Council for the Environment and Infrastructure of the Netherlands, Dutch Logistics 2040, Designed to Last (2013), p.7
[102] TNO, Opportunities for a Circular Economy in the Netherlands (2013), p.13-14
[102] Council for the Environment and Infrastructure of the Netherlands, Dutch Logistics 2040, Designed to Last (2013), p.42
[103] TNO, Opportunities for a Circular Economy in the Netherlands (2013), p.13-14
[103] Council for the Environment and Infrastructure of the Netherlands, Dutch Logistics 2040, Designed to Last (2013), p.49
[104] Ellen MacArthur Foundation Report Volume 1 (2012), p.37
[105] Chatham House, 'A Global Redesign? Shaping the Circular Economy' (2012), p.37
[106] COWI, Economic Analysis of Resource Efficiency Policies (2011), p.64

Food sector	UK government[107]	Courtauld commitment (voluntary agreement): retailers should cut food and packaging waste by 1.2million tons in Phase 1 (2005-10), and by a further 8.8% in the first two years of Phase 2 (2010-12)	During the second phase of the Courtauld Commitment, 1.7 million tonnes of waste was prevented, carbon impact in the grocery packaging was reduced by 10% and EUR 3.7 billion (3.1 billion pounds) were saved[108] x
Food sector	Too Good to Waste (Netherlands)[109]	Processing supermarket fruit and vegetables which are close to their expiry date into juice and soup instead of throwing them away (non-profit activity?/ organisation?)	600 million euros per years' worth of food saved
Maritime Transport	MAERSK[110]	Creating a cradle to cradle passport for their new Triple-E ships to reuse the steel more effectively and respond to steel price volatility	The 60,000 tonnes of steel per used ship and other materials can be sold at a higher price because the characteristics and value of each component are compiled in the online database
Automobile	Renault[111]	vehicles with the eco² mark are designed so that 95% of their mass can be recovered at end-of-life to be reused or recycled	
Automobile	Renault[112]	Its Choisy plant (greater Paris) specialises in the reconditioning of powertrains. Sub-standard parts are sent to the appropriate recycling process	Apart from the environmental benefits, this also allows the plant to control its waste treatment costs. Globally, Renault's remanufacturing operations represent EUR 200 million
Light commercial vehicles	See EMF report Volume 2[113]	Refurbishment is a profitable alternative • Improving vehicle design and focusing on exchanging the 'weakest link' components, which are most likely to break first, allows for a second usage period at full performance (i.e., 100,000 km p.a.): the engine and suspension, bumpers, wheels, battery, and fluids. Design changes enable easier, faster, and less expensive replacement of these components. • Establishing professional	Although collection rates of vehicles at the end of their final usage period (deregistration) are already as high as ~71%, partially due to stringent EU directives, shifting volumes from recycling to refurbishing still saves substantial material inputs by roughly USD 8.8 billion (i.e., 15% of material budget) annually.

[107] ESA, Going for Growth (2013), p.6

[108] http://www.wrap.org.uk/sites/files/wrap/Courtauld%20Commitment%202%20Final%20Results.pdf, last accessed 21/02/2014

[109] Council for the Environment and Infrastructure, Dutch Logistics 2040: Designed to Last (2013), p.54

[110] http://www.ellenmacarthurfoundation.org/case_studies/maersk, last accessed 14/02/2014

[111] Chatham House, 'A Global Redesign? Shaping the Circular Economy' (2012), p.37

[112] European Resource Efficiency Platform, Working Group I, Circular Economy / Greening the Economy, First Report to Sherpas (2012), p.6

[113] Ellen MacArthur Foundation, Report Volume 2 (2012), p.45

		refurbishing systems within the OEM's dealership and service network to capture economies of scale in the reverse supply chain—by investing in proper tooling and achieving higher labour efficiency through process standardisation, workflow optimisation, and specialisation.	

D. Priority material flows

The second approach to establish priority areas for increased circularity and resource efficiency takes a material flows, as opposed to sectors and products perspective. Indeed, certain reports already select particular material flows as a priority for future policies.

- The Commission report on the evolution of waste reduction and prevention uses the Multi Criteria Analysis (MCA) methodology to determine specific material streams that have the highest potential for resource efficiency when combined to certain policy strategies. The results found are that **hazardous waste**, **plastics** and **metals** have the highest potential for prevention.[114]
- The Ellen MacArthur report n°2 also emphasises **metals** as a priority material.[115]
- These flows are the most promising especially when combined to certain prevention strategies[116]
  - Hazardous waste: Ecodesign, GPP, financial stimuli, product standards and technology standards
  - Metals: labelling/certification, marketing, financial stimuli, product standards and technology standards
  - Plastics: Ecodesign
- They have been established as priority material flows after exploring their potential for quantitative and qualitative prevention as well as life cycle aspects such as their future availability, impact on greenhouse gas emissions and possible alterations of the material through time.[117]
- The Council for the Environment and Infrastructure of the Netherlands's report[118] emphasises **chemicals** as an important material flow to improve resource efficiency.
- A Green Alliance report[119] presents **metals** and **phosphorus** as priority material flows, not because of their potential for circularity but because they are economically critical and are becoming very rare.

[114] Analysis of the evolution of waste reduction and the scope of waste prevention (2010), Table 58, p.241
[115] Ellen MacArthur Foundation, Report Volume 2 (2012)
[116] Analysis of the evolution of waste reduction and the scope of waste prevention (2010), Table 58, p.241
[117] Analysis of the evolution of waste reduction and the scope of waste prevention (2010), p.219
[118] Council for the Environment and Infrastructure of the Netherlands, Dutch Logistics 2040, Designed to Last (2013), p.7

- The Netherlands Organisation for Applied Scientific Research (TNO)'s report also cites **metals** as a priority.[120]
- **Biotic flows** are also crucial to increase circularity and resource efficiency. The Council for the Environment and Infrastructure of the Netherlands's report estimates for instance that 34 biotic waste streams (sewage sludge, feather meal, cattle slurry, potato pulp, cocoa shells, fish waste, etc.) could generate **a net added value of €1 billion per year** for the Dutch economy.[121] Such potential should also be benefited from at a European level.

The criteria to determine priority material flows are thus multiple: potential for circularity and resource efficiency, economic benefits, importance of the material to the economy, etc.

From these reports, it is clear that metals, chemicals, phosphorus and, secondly, biotic flows represent priority material flows for the circular economy.

The table below shows some public and private initiatives to improve the circularity of material flows (both biotic and abiotic) and extrapolates the positive impact of some local or national initiatives they could have on a European Union scale. Priority flows are presented first but other material flows are also considered.

Table 2: Examples of initiatives to improve the circularity of material flows

Sector	Actors	Initiative	Impact of Initiative
Metals	Umicore[122]	Integrated modern metal processing complex	Can recover up to17 metals with recovery efficiencies of 95% or more
Steel	See EMF report volume 2[123]	*(McKinsey Global projections)*	For steel, the global net material savings could add up to more than 100 million tons of iron ore in 2025 if applied to a sizeable part of the material flows (i.e., in the steel-intensive automotive, machining, and other transport sectors, which account for about 40% of demand).
Aluminium	Swedish government[124]	Producers of canned beverage and importers of metal beverage cans are required to join an approved deposit-based recycling system with a target of 90%. Consumers pay a deposit for every can purchased of EUR 0.052	• Generated financial result: EUR 520/tonne of aluminium scrap • Average annual deposit not reclaimed by consumers: EUR 15.1 million • The potential at an EU scale is of EUR 19.6 million of Annual economic benefit to operators
Aluminium	Belgian	Belgian companies packaging or	• Total income from selling aluminium

[119] Green Alliance, Reinventing the Wheel (2011), p.3
[120] TNO, Opportunities for a Circular Economy in the Netherlands (2013), p.13-14
[121] TNO, Opportunities for a Circular Economy in the Netherlands (2013)
[122] Schulte, Uwe G., New business models for a radical change in resource efficiency(2013), p.4
[123] Ellen MacArthur Foundation Report Volume 2 (2012), p.67
[124] COWI, Economic Analysis of Resource Efficiency Policies (2011), p.72

	government[125]	arranging for the packaging of products sold in Belgium are liable to collect used packaging material to achieve a recovery rate of 90% and recycling rate of 80%. Household metal packaging waste is collected in special-purpose waste containers	scrap from cans: EUR 1.727-2.591 million • EU scale: Economic benefit in the magnitude of EUR 7.4-28 million
Rare metals[126]		Figures are from Dr Christian Hagelüken's presentation for the Green Alliance seminar on resource security from 2011	The 1.3 billion mobile phones produced every year account for 12,000 tonnes of copper, 325 tonnes of silver, 31 tonnes of gold, and 12 tonnes of palladium
Rare metals	Veolia ES Technical Solutions in West Bridgewater, Massachussetts[127]	Electronics recycling facility for the latest state-of-the-art recycling equipment for fluorescent lamps, ballast, batteries, computers, electronics and mercury-bearing waste. It is capable of recovering more than 99% by weight of a fluorescent lamp (glass, aluminium mercury-bearing phosphor power and mercury)	7000 tonnes of lighting and electronic waste are processed annually and over 70 kg of elemental mercury is reclaimed from recycling fluorescent lamps. This facility replaces one in Stoughton and is expected to increase capacity for fluorescent lamps by 150%
Chemicals	Austria[128]	Chemical leasing trial where the focus is not on selling as much volume as possible, but on ensuring the product is optimally efficient and effective by providing technical information	reduction in costs of 15% on raw materials used and of 1/3 in the amount of solvent used per car
Phosphorus	China, US[129]	The diminishing reserves of phosphate rock are alarming for agriculture. A solution in the few countries that have phosphorus rock reserves has been the Imposition of export restrictions. Another solution would be addressing secondary sources of phosphate (manure, human sewage, food and crop residues), financing recycling and recovery through a product levy (no results are available).	
Industrial	See EMF report	Cascaded uses for industrial	An additional profit of 1.9 to 2 USD$ per

125 COWI, Economic Analysis of Resource Efficiency Policies (2011), p.72

126 Hannah Hislop and Julie Hill, *Green Alliance*, 'Reinventing the wheel: a circular economy for resource security' (2011), p.14

127 http://www.waste-management-world.com/articles/2013/08/veolia-e-waste-recycling-facility-to-recover-mercury-rare-earths-in-u-s.html, last accessed 21/02/2014

128 CEI, Dutch Logistics 2040, Designed to Last (2013), p.47

129 Hannah Hislop and Julie Hill, *Green Alliance*, 'Reinventing the wheel: a circular economy for resource security' (2011), p.28

beverage processing waste	volume 2	beverage processing waste. *Cascaded uses are relevant for many food processing by-products.*	hectolitre of beer produced could be created in Brazil on top of the margin for beer by selling the biggest waste product, i.e. brewer's spent grains, to farmers in the fish farming (specifically tilapia) and livestock sectors, thus 'cascading' it to another industry as a feed supplement.
Household food waste	See EMF report volume 2	Collect household food waste and processing it to generate biogas and return nutrients to agricultural soils	An income stream of $1.5 billion could be generated annually in the UK alone for municipalities and investors
Food waste	Korean government[130]	Food waste reduction: Part of a management plan, which contains different food waste reduction programmes	• The food waste recycling rate went from 21.7% in 1998 to 92.2% in 2007 • Internal production of animal feed / fodder to replace imports could save EUR 10,400 million/year for livestock holders
Organic waste	Equimeth project[131] (France)	Methanisation of horse waste in the area close to the Fontainebleau forest where there are numerous stables	40 000 tons of organic waste is methanised every year instead of being transported, substituting fossil fuel (natural gas) by renewable energy (biomethane) and decreasing greenhouse gas emissions
Cross-sector	North Rhine-Westphalia[132]	PIUS-Check (Production-integrated environment protection): EFA initiative to promoting cleaner production methods in SMEs (metal processing, metal finishing, food processing industries)	At an EU scale: • EUR 776 million, if the same % of SMEs accept the PIUS check • EUR 333,000 over 10 years for SMEs

These initiatives show that material as well as economic savings are possible for priority material flows by increasing their recovery and reuse (Umicore, Swedish and Belgian initiatives for beverages cans, Veolia).

For chemicals, changing the business model from quantity to quality-based criteria could help limit the use of raw materials.

Finally, an important part of these initiatives show that there is significant potential in biotic flows that are usually not recovered such as manure, grains or household waste.

[130] COWI, Economic Analysis of Resource Efficiency Policies (2011), p.81
[131] IAU, Economie circulaire, écologie industrielle (2013), p.43
[132] COWI, Economic Analysis of Resource Efficiency Policies (2011), p.66

VI. Annexes

Table 3: Priority sector/products and priority material flows

DG ENV: Circular economy	Products and materials																	
		Biomass materials						Metals				Minerals						
Product Family	*Product Categories*	Crops	Livestock	other marine / aquatic animals	Grass	Crop residues	Wood	Ferrous metals	Copper	Bauxite / Aluminium	Other metals	Precious metals and rare earths	Marble, granite, stone, slate	Chalk and dolomite	Chemical and fertilizer minerals	Salt	Limestone and gypsum	Clays and kaolin
Food	Meat & meat procucts	Input: feed		Input: feed?	Input: grazing	Input: straw												
	Milk, eggs and dairy products	Input: feed	Output of lives	Input: feed?	Input: grazing	Input: straw												
	Fish and other seafood products	Input: feed		Input: feed														
	Fruit & vegetables														Input: fertilizer for crops			
	Oil and fats	Oil crops	Butter and lard	Fish oil											Input: fertilizer for crops			
	Beverages (non-alcoholic & alcoholic)	Barley - beer, grapes - wine, sugar													Input: fertilizer for crops			
	Bread, cakes and other bakery products	Wheat, sugar													Input: fertilizer for crops			
	Coffee & tea														Input: fertilizer for crops			
	Grains & pasta	Cereals													Input: fertilizer for crops			
	Sugar	Sugar cane and sugar beet													Input: fertilizer for crops			
	Others (processed foods, etc.)																	
	Animal feed																	
	Tobacco																	
	Packaging						Pallets, wood	Cans and containers		Cans, foils and containers								
	Basic ferrous metal products											Alloys						
	Fabricated metal products											Alloys						
Transport	Cars	Parts: rubber t	Parts: leather									Electronic equipment and alloys						
	Aircraft	Parts: rubber t	Parts: leather									Electronic equipment and alloys						
	Trucks	Parts: rubber tyres and textiles										Electronic equipment and alloys						
	Ships and boats	Parts: rubber a	Parts: leather									Electronic equipment and alloys						
	Motorcycles	Parts: rubber tyres and textiles										Electronic equipment and alloys						
	Bicycles	Parts: rubber tyres																
	Rail locomotives and rolling stock	Parts: rubber and textiles										Electronic equipment and alloys						
	Other transport equipment											Electronic equipment and alloys						
	Tyres																	
	Generators and motors (ICE)	Rubber parts										Electronic equipment and alloys						
	Telephones											Electronic equipment and alloys						
	Home entertainment equipment (TVs, projectors, sound systems, etc.)											Electronic equipment and alloys						
	Toys, leisure and sports equipment											Electronic equipment and alloys						
	Medical devices											Electronic equipment and alloys						

Source: BIO by Deloitte

1. Bibliography for the literature review

Table 4: List of studies analysed in-depth in the literature review

Year	Type	Authors	Hyperlink	Organisation/ Journal/ Event	Study Title
2012	Report		http://www.ellenmacarthurfoundation.org/business/reports/ce2012#	Ellen MacArthur Foundation *(Report Vol. 1)*	Towards the circular economy : Economic and business rationale for an accelerated transition
2013	Report		*http://www.ellenmacarthurfoundation.org/business/reports/ce2013*	Ellen MacArthur Foundation *(Report Vol. 2)*	Towards the circular economy : Opportunities for the Consumer Goods Sector
2013	Report	Ton Bastein, Elsbeth Roelofs, Elmer Rietveld,	http://blogs.ec.europa.eu/orep/opportunities-for-a-circular-economy-in-the-netherlands/	The Netherlands Organisation for Applied Scientific Research (TNO)	Opportunities for a circular economy in the Netherlands

Year	Type	Authors	Hyperlink	Organisation/ Journal/ Event	Study Title
		Alwin Hoogendoorn			
2011	Report	Hannah Hislop and Julie Hill	http://www.green-alliance.org.uk/reinventing_the_wheel/	Green Alliance	Reinventing the wheel: a circular economy for resource security
2012	Report	Steve Wallace (Aldersgate Group Director) and Andrew Raingold (Executive Director)	http://www.aldersgategroup.org.uk/reports	Aldersgate Group	Resilience in the Round - Seizing the growth opportunities of a circular economy
2012	Report	Felix Preston	http://www.chathamhouse.org/publications/papers/view/182376	Chatham House	A Global Redesign? Shaping the Circular Economy
2010	Commissioned by the EU/EEA		http://ec.europa.eu/environment/waste/prevention/reports.htm	Arcadis, BIO Intelligence Service, VITO and Umweltbundesamt	Analysis of the evolution of waste reduction and the scope of waste prevention
2009	Report	Sarah Winne, Sarah Standley	http://enworksinabox.com/sites/default/files/SDRN%20Business%20Resource%20Efficiency%20Report%202009.pdf	AEA Technology plc.	Business Resource Efficiency. Report to the Sustainable Development Research Network
2011	Commissioned by the EU	Victor Hug, Lillah Lucie Emmik Sørensen, Bettina Bahn-Walkowiak, Rob Williams	http://ec.europa.eu/environment/enveco/resource_efficiency/pdf/economic_analysis.pdf	COWI Consulting Group	Economic Analysis of Resource Efficiency Policies
2013	Report *(available only in French)*	, Sandrine Gueymard, Cristina Lopez	http://www.iau-idf.fr/fileadmin/Etudes/etude_1038/Economie_circulaire_Ecologie_industrielle_IdF.pdf	Institut d'aménagement et d'Urbanisme (IAU) Ile -de-France	Economie circulaire, écologie industrielle, Eléments de réflexion à l'échelle de l'Ile-de-France
2013	Report	Jacob Hayler, Toni Waters	http://www.esauk.org/esa_reports/Circular_Economy_Report_FINAL_High_Res_For_Release.pdf	Environmental Services Association (ESA)UK	Going for Growth: A practical route to a Circular Economy

Year	Type	Authors	Hyperlink	Organisation/ Journal/ Event	Study Title
2013	Report	Uwe G. Schulte	http://www.sciencedirect.com/science/article/pii/S221042241300066X	Environmental Innovation and Societal Transitions, ScienDirect	New business models for a radical change in resource efficiency
2013	Report		http://www.rli.nl/sites/default/files/dutch_logistics_2040_designed_to_last__uk_versie.pdf	Council for the Environment and Infrastructure	Dutch Logistics 2040, Designed to last
2013	Report *(available only in French)*		Accessed via FACTIVA	Droit de l'environnement, n° 218	Évolution du statut de déchet : une contribution à l'économie circulaire ?

Below are reading notes of each of these studies that present the detail of the documents used for the synthesis.

A. Towards the circular economy: Economic and business rationale for an accelerated transition

Year	Type	Authors/ Organisation	Abstract
2012	Report	Ellen MacArthur Foundation (Report Vol 1)	Eliminating waste from the industrial chain by reusing materials to the maximum extent possible promises production cost savings (EUR 250 to 280 billion p.a. at EU level for a 'transition scenario') and less resource dependence. The report analyses about a dozen mainstream products reflecting various circular design concepts.

Definition of a circular economy

The idea is "to shift from a linear model of resource consumption that follows a 'take-make-dispose' pattern, to an industrial economy that is 'restorative by intention'; i.e. that 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".

Principles of a circular economy

First, at its core, a circular economy aims to 'design out' waste. Waste does not exist—products are designed and optimised for a cycle of disassembly and reuse. These tight component and product cycles define the circular economy and set it apart from disposal and even recycling where large amounts of embedded energy and labour are lost.

Secondly, circularity introduces a strict differentiation between consumable and durable components of a product. Unlike today, consumables in the circular economy are largely made of **biological ingredients or 'nutrients'** that are at least non-toxic and possibly even beneficial, and can be safely returned to the biosphere—directly or in a cascade of consecutive uses. Durables such as engines or computers, on the other hand, are made of **abiotic nutrients** unsuitable for the biosphere, like metals and most plastics. These are designed from the start for reuse.

For technical nutrients, the circular economy largely **replaces the concept of a consumer with that of a user**. This calls for a new contract between businesses and their customers based on product performance. Unlike in today's 'buy-and-consume' economy, durable products are leased, rented, or shared wherever possible. If they are sold, there are incentives or agreements in place to ensure the return and thereafter the reuse of the product or its components and materials at the end of its period of primary use.

Thirdly, the energy required to fuel this cycle should be renewable by nature, again to decrease resource dependence and increase system resilience (e.g., to oil shocks).

Barriers and drivers

Type of barrier	Examples of drivers and strategies	Possible challenges/barriers
Institutional and organisational	**New business models:** 'Consumer as user', i.e. that products become services such as in a deposit payment and leasing model. **Cross-cycle and cross-sector collaboration** facilitating factors, e.g. **joint product development and infrastructure management** through: - IT-enabled transparency and information sharing; - Joint collection systems; - Industry standards; - Aligned incentives; - Match-maker mechanisms.[133]	In a leasing business model, challenges may arise in the cooperation with business partners, which can hinder a new business model from becoming effective and profitable. Adopting more circular business models will therefore require skills in new forms of collaboration and alliance-building.
Cultural and consumer acceptance	Free servicing, easy trade-in for upgrades, convenience/ incentive to return goods, high-end machines with hardly any upfront costs, etc., should be marketed adequately.	

[133] Ellen MacArthur Foundation, report n°2 (2012)

Policy and regulatory	Resource and labour market economists have long argued that labour as a 'renewable factor input' is currently penalised over material and non-renewable inputs in most developed economies. They promote a shift of the tax burden away from labour/income and towards non-renewable resources. Furthermore, EU should consider adding products with high recycled content to the list of VAT reduced goods.	**Taxation** today largely relies on labour income.
Technological and infrastructural	**Design and production**: - Material choice optimised for circular setup; - Design to last; - More modularisation/ standardisation; - Easier disassembly and higher refurbishment potentialities; - Production process efficiency.	

Impact assessment of circular economy initiatives in specific value chains and sectors (cost & benefit analysis)

Electronic goods

- The cost of remanufacturing **mobile phones** (notably smartphones) could be reduced by **50%** per device—if the industry made phones easier to take apart, improved the reverse cycle, and offered incentives to return phones.
- High-end **washing machines** would be accessible for most households if leased instead of sold—customers would **save a third per wash cycle**, and the manufacturer would **earn a third more in profits**. Over a 20-year period, replacing the purchase of five 2,000-cycle machines with leases to one 10,000-cycle machine would yield almost **180 kg of steel savings** and more than **2.5 tonnes of CO_2 savings**.
- **Ricoh**, provider of **printing machines**, office solutions and IT services, developed '**GreenLine**' to minimise the environmental impact of products at its customers' sites. Copiers and printers returning from their leasing programme go through an **extensive renewal process**—including key components replacement and software update—before re-entering the market under the GreenLine label with the same warranty scheme that is applied to new devices. Because it increases customers' choice, the programme is a success and keeps pace with Ricoh's new equipment sales. Its 'objectives are to reduce the input of new resources by 25% by 2020 and by 87.5% by 2050 from the level of 2007; and to reduce the use of—or prepare alternative materials for—the major materials of products that are at high risk of depletion (e.g., crude oil, copper, and chromium) by 2050'.[134] *[Economic impact are not given in the report]*

Food

[134] Ellen MacArthur Foundation, http://www.ellenmacarthurfoundation.org/business/articles/snapshot-ricoh, last accessed 18/02/2014

The U.K. could save **USD 1.1 billion a year on landfill cost** by keeping **organic food waste** out of landfills—this would also reduce greenhouse gas emissions by **7.4 million tonnes p.a.** and could deliver up to **2 GWh worth of electricity** and provide much-needed soil restoration and specialty chemicals.

Automotive sector

- **Light commercial vehicles** – Looking at the technical and economic break points, only a minor fraction of components is responsible for the degradation in van performance.
- **Improving vehicle design** and focusing on **exchanging the 'weakest link' components**, which are most likely to break first, allows for a second usage period at full performance (i.e., **100,000 km p.a.**): the engine and suspension, bumpers, wheels, battery, and fluids. Design changes enable easier, faster, and less expensive replacement of these components, e.g., modularisation of the engine by changing the design to bracket mounting, etc.
- **Establishing professional refurbishing systems** within the OEM's dealership and service network to capture economies of scale in the reverse supply chain—by investing in proper tooling and achieving higher labour efficiency through process standardisation, workflow optimisation, and specialisation.
- Although collection rates of vehicles at the end of their final usage period (deregistration) are already as high as ~71%, partially due to stringent EU directives**, shifting volumes from recycling to refurbishing** still saves substantial material inputs by roughly **USD 8.8 billion** (i.e., 15% of material budget) annually.
- At **Renault**'s remanufacturing plant near Paris, France, several hundred employees **re-engineer 17 different mechanical subassemblies**, from water pumps to engines. Renault works with its distributor network to obtain used subassemblies, and supplements these with used parts purchased directly from end-of-life vehicle disassemblers as well as with new parts where necessary. Renault's ability to **structure and run its reverse logistics chain** and access a steady stream of cores, together with its deployment of highly skilled labour, has allowed the company to grow its remanufacturing operations into a **200m € business**.
- In the 1920s, **Michelin** pioneered leasing tyres under a pay-per-kilometre programme. As of 2011, Michelin Fleet Solutions had **290,000 vehicles** under contract in 23 countries, offering tyre management (upgrades, maintenance, replacement) to optimise the performance of large truck fleets—in Europe, **50% externalise their tyre management**. By controlling the tyres throughout their usage period, Michelin can easily collect them at the end of the leases and extend their technical life (for instance by retreating) as well as to ensure proper reintegration into the material cascade at end of life.

Textiles

In the textile sector, cascading use keeps materials in circulation for a longer period of time:

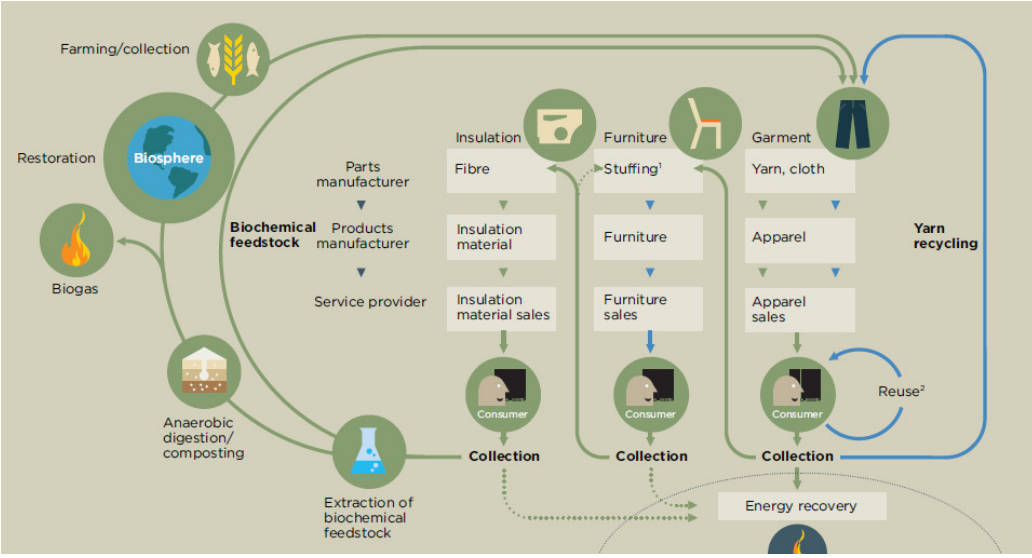


Figure 4: example of cascading use for clothing, which becomes furniture and then insulation

Construction

- While many long-lived assets such as buildings and road infrastructure consist largely of metals, minerals, and petroleum-derived construction materials (i.e., technical nutrients), there is also a **significant role for bio-based materials** such as various kinds of wood.
- Initiatives have demonstrated the **potential for value retention**—a pilot in **Riverdale, MD (USA)** showed that deconstructing rather than demolishing U.S. houses built in the 1950s and 1960s would **divert 76% of the rubble** produced from going to landfill, avoiding the associated landfill cost and preserving valuable building components and materials for recycling and reuse.
- **Deconstruction case studies** show important **social benefits**, including significant increases in labour requirements, job creation at a local level, and better employment conditions and educational opportunities. If it were fully integrated into the U.S. demolition industry, which takes down about 200,000 buildings annually, the equivalent of **200,000 jobs** would be created'.[135]
- Leading construction companies like **Skanska**, a Swedish project development and construction group with worldwide activities, have made the possibilities of deconstruction an inherent part of their strategy and services portfolio.
- In Japan, **Kajima Construction Corporation** developed a new deconstruction technique that allowed it to **recycle 99%** of the **steel** and **concrete** and **92% from a building**. The Japanese government has supported deconstruction through legislation and policies.
- In the **U.S.**, local, state, and federal agencies encourage **deconstruction programmes** for their beneficial effects on employment and community building, which might explain why the private sector take-up has been limited, and deconstruction activities are currently largely the domain of smaller local players.

[135] Brian Milani, Building Materials in a Green Economy: Community-based Strategies for Dematerialization, 2001

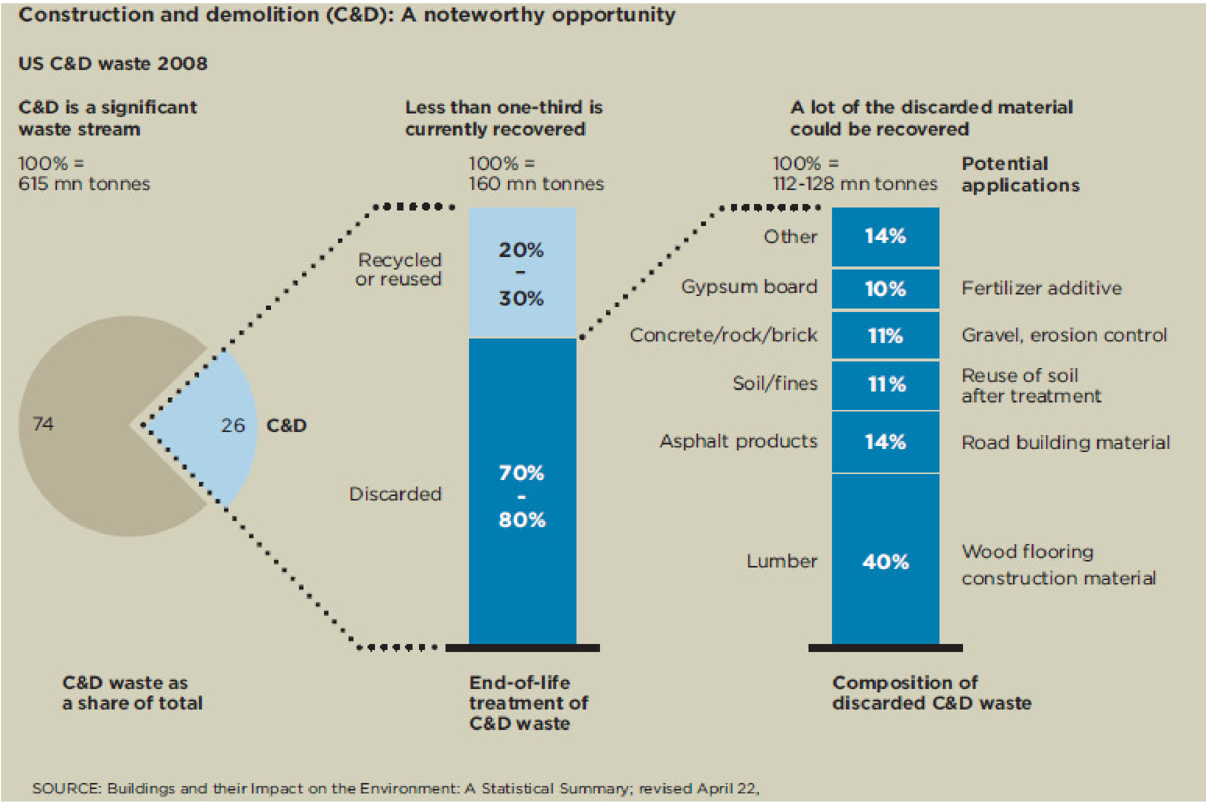


Figure 5: Construction and demolition waste potential applications

Steel

For steel, the global net material savings could add up to more than **100 million tonnes** of iron ore in 2025 if applied to a sizeable part of the material flows (i.e., in the steel-intensive automotive, machining, and other transport sectors, which account for about 40% of demand).

B. Towards the circular economy: Opportunities for the Consumer Goods Sector

Year	Type	Authors/ Organisation	Abstract

2012	Report	Ellen MacArthur Foundation (EMF)	It is the 2nd EMF report on Circular Economy, featuring analysis from McKinsey, which makes the case for a faster adoption of the concept, quantifies the economic benefits of circular business models, and lays out pathways for action. The report focuses on fast-moving consumer goods, which currently account for about 60% of total consumer spending, 35% of material inputs into the economy, and 75% of municipal waste. Importantly, the consumer goods sector absorbs more than 90% of the world's agricultural output – possibly the most embattled resource in the future. The **global** economic opportunity of circular economy for the consumer goods sector is worth EUR 515 billion. *In EMF report n°1 (2010), eliminating waste from the industrial chain by reusing materials to the maximum extent possible promised production cost savings of EUR 250 to 280 billion p .a.* ***at EU level****.*

Definition of a circular economy

Same definition as in the 1st EMF report (2010).

However, here the circular economy is seen under the angle of consumption: "modern circular and regenerative forms of consumption", from anaerobic digestion of household waste to apparel recovery.

Barriers and drivers

Type of barrier/ driver	Examples of drivers and strategies	Possible challenges/barriers
Institutional and organisational	New business models: rental schemes, reverse logistics chains to cascade materials to other applications, etc. Municipalities can foster the build-up of reverse infrastructure, with information events and suitable nudges in the form of city ordinances. Circular design product and production	
Cultural and consumer acceptance		Acceptance or rental schemes will require raising awareness among consumers

Type of barrier/ driver	Examples of drivers and strategies	Possible challenges/barriers
Policy and regulatory	More **extended producer responsibility** (EPR) regulation, for instance to help accelerate the scale-up of circular packaging systems, by transferring the burden (or the incentive to innovate) to manufacturers. EPR would deliver better design of product packaging for reducing, reusing and recycling. It would also encourage investment in better end-of-life solutions, for example collection, sorting and recycling infrastructure. **Ban toxic materials** (e.g., PVC) and **modify accounting systems to price in externalities** (e.g., landfill costs, energy consumption and carbon emissions). **Taxes and mandatory deposits** on single-use packaging. Establish standards and guidelines, but limited certification guidelines.	
Access to financing	Shift local authority spending from landfill to anaerobic digesters or industrial composters, e.g. via incentives or higher landfill taxes. Give access to preferred credit conditions to companies taking innovating initiatives. Besides government funding, public- private organisations also play a crucial role, for example in circular systems for soil nutrients.	
Technological, infrastructural and economical	Develop anaerobic digester and/ or industrial composter technology and operating procedures to readily turn biodegradable packaging into digest compost (e.g. facilitated via incentives for accepting biodegradable packaging). Designing packaging intentionally for durability and re-use (thicker walls, anti-scuffing technologies)	There is a **lack of infrastructure** for biodegradable packaging, and **lack of volume**.

Impact assessment of circular economy initiatives in specific value chains and sectors (cost & benefit analysis)

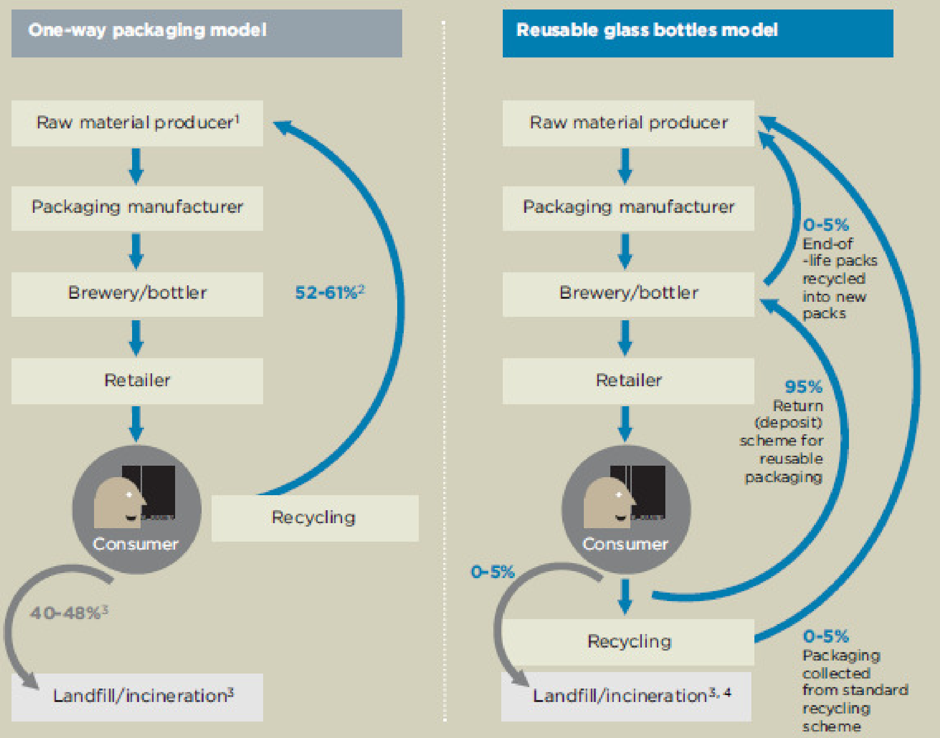
<u>Household food waste</u>

- An **income stream of $1.5 billion** could be generated annually in the UK alone for municipalities and investors by collecting **household food waste** and processing it to generate **biogas and return nutrients to agricultural soils**.
- **Coffee production** generates 12 million tonnes of agricultural **waste** per year. This waste could be used to **replace hardwoods** traditionally used as growth media **to farm high-value tropical mushrooms, a market with double-digit growth** (currently USD 17 billion globally). Coffee waste is in fact a superior medium, as it shortens the production period. The residue (after being used as a growth medium) can be reused as livestock feed, as it contains valuable enzymes, and can be returned to the soil in the form of animal manure at the end of the chain.

Packaging

A **cost reduction of 20% per hectolitre of beer** sold to consumers would be possible across all markets by shifting from disposable to reusable glass bottles, which would lower the cost of packaging, processing, and distribution.

FIGURE 17 **Beer packaging shows potential for far greater circularity in many markets**



1 Example: PET resin, glass cullet, aluminium blocks
2 Recycling - Plastic bottles 52%, aluminium cans 60%, glass bottles 61%
3 Incineration ("waste to energy") of PET bottles, if done cleanly, is preferable to landfilling
4 Additional glass in municipal waste streams may be sorted in mixed-waste material recovery facility (MRF), but unlikely to be back into food-grade glass bottles due to regulations

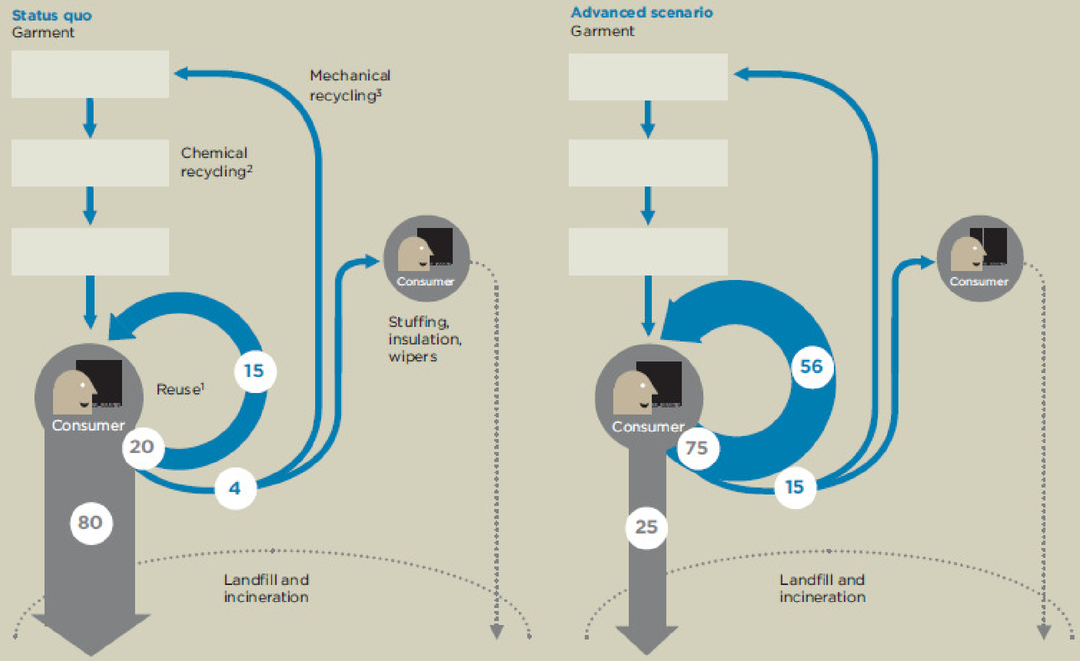
SOURCE: WRAP, press searches, expert interviews, Ellen MacArthur Foundation circular economy team

Textiles

There are profitable circular opportunities to reuse end-of-life clothing, which, in addition to being worn again, can also be cascaded down to other industries to make insulation or stuffing, or simply recycled into yarn to make fabrics that save virgin fibres. If sold at current prices in the U.K., **a tonne of collected and sorted clothing can generate a** revenue of USD 1,975, or **a gross profit of USD 1,295 after subtracting the USD 680 required to collect and sort each tonne**. We also see an opportunity in expanding the 'clothing-for-hire' segment to everyday clothes, as another offshoot of the asset-light trend.

FIGURE 11 **Clothing: Further increasing circularity through greater collection and closed-loop recycling, both mechanical and chemical**

End-of-life material flows for Europe and North America Percentage of total end-of-life clothing weight

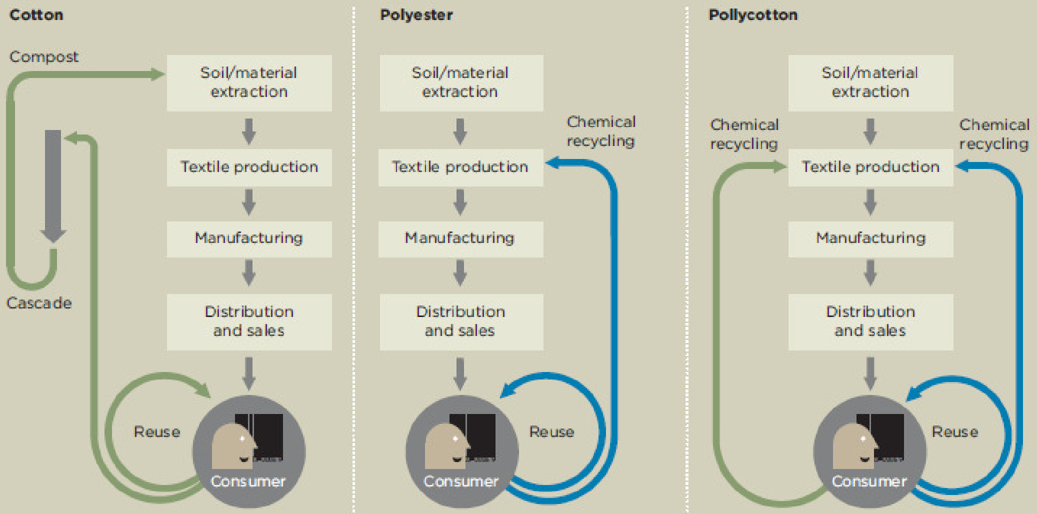


Note: All fibres treated as technical materials since most dyes and coatings used today mean that even natural fibres cannot be returned to the soil
1 Includes both domestic reuse within the UK and reuse exported abroad
2 Describes process to depolymerise and repolymerise fibres to create new fibres of similar quality to virgin production. Minimal chemical recycling currently of polyester (Teijin) in Japan and nylon (e.g., Aquafil)
3 Describes process to shred and card fibres, then make new yarns and clothing (e.g., Marks & Spencer 'shwopped coat')

SOURCE: WRAP 'Valuing our clothes' 2012; WRAP 'Textile Flow and Market Development Opportunities 2012, Ellen MacArthur Foundation circular economy team

FIGURE 12 **Clothing: In the ideal state, biological and technical materials should be kept separate or separated at end of life using new technologies**

End-of-life material pathways for biological and technical products



Maintain separation throughout use: Natural fibres (e.g. cotton) are kept pure in each cycle including ensuring dyes and coatings used in cascades are non-toxic and can be reurned to the earth (e.g. Climatex Lifecycle)

Maintain separation throughout use: Polyester is kept pure and, through the chemical process, is returned to the same quality as virgin polyester for use in new production (e.g, Teijin technology)

End-of-life separation: Blended fibres are processed at the end of life to separate polyester and cotton to produce new polyester and cellulose used in the production of viscose (e.g, Worn Again technology)

SOURCE: Ellen MacArthur Foundation circular economy team

	Changing variables	**Europe**	**North America**	**Rest of World**
Food and beverages: households and retail	Volume collected	• Status quo U.K. 30%, rising to 75%	• Status quo U.S. 2%, rising to 50%	• 12% rising to 30%
	Value	All materials values assumed to be the same globally (e.g., electricity, heat, fertiliser)		
Food and beverages: production	Volume	• Higher collection rate due to more efficient infrastructures	• Higher collection rate due to more efficient infrastructures	• Lower collection rate due to lack of infrastructure
	Value	All materials values assumed to be the same globally[1]		
Clothing	Volume	• Medium initial collection rate (25%) rising to 40% and 65%	• Low initial collection rate (15%) rising to 35% and 55% in transition and advanced scenarios • Chemical recycling increased from 0% to 9% in advanced scenario	• High initial collection rate (65%) rising to 75% and 90% in the transition and advanced scenarios • No chemical recycling
	Value	All materials values assumed to be the same globally (e.g., t-shirts, trousers)		
Packaging[2]	Volume	• 7% rising to 34% • Significant opportunities for reuse in some countries and for recycling in all	• 8% rising to 44% • Largest opportunity due to low base (reuse and recycling)	• 7% rising to 23% Reuse already prevalent driven by entrepreneurial sector; opportunities for recycling
	Value	All materials values assumed to be the same globally (e.g. glass, PET, alluminium)		

C. Opportunities for a circular economy in the Netherlands

Year	Type	Authors/ Organisation	Abstract
2013	Report	Bastein, Ton, Roelofs Elsbeth, Rietveld Elmer, Hoogendoorn Alwin TNO	This report analyses the opportunities and obstacles that will present themselves as the Netherlands moves towards a more circular economy. It proposes a number of actions that could be taken, particularly by the government, to accelerate this process. The analysis focuses on the overall Dutch economy, but it begins by examining two cases : 1. The abiotic circular economy : products from the metal and electrical sectors 2. The biotic circular economy: waste streams from the agro-food sector used as raw materials.

Definition of a circular economy

The global **consumption** of materials is expected to **triple by 2050.** In order not to run out of resources, we will have to find ways that lead to even greater prosperity for more people and that put less pressure on the environment in absolute terms – what is referred to as '**absolute decoupling**'.

A **circular economy** is an **economic** and **industrial system** based on the **reuse** of products and raw materials, and the restorative capacity of natural resources. It attempts to **minimize value destruction** in the overall system and to maximize value creation in each link in the system. In the transition to a circular economy the focus is no longer solely on decoupling environmental pressures from economic growth, but also on the **opportunities created if resource consumption and economy remain coupled**. The complex value chains that characterize our global economy make chain optimization difficult however. In that sense a **two-track policy**, in which existing developments are driven by the 'pack', with 'frontrunners' embracing the principle of a circular economy, could be an interesting solution.

As circularity increases, **there will be losers at first**: as more goods are reused and repaired, fewer new goods will be bought, which in turn means a loss of income for manufacturers, transporters and dealers. In this case we assume that an increase in the number of products reused and repaired has a reciprocal effect on purchases of new products, that the reuse of components leads to a gradual decline in purchases (we assume by 75%) and that an increase in recycling does not affect purchases of new products.

Barriers and drivers

Type of barrier/ driver	Examples of drivers and strategies	Possible challenges/barriers
Institutional and organisational	- The government should encourage the foundation of an extensive raw materials information service - To deal with uncertainty and still provide direction when possible requires the government to assume a learning attitude	- If the potential costs of a new design/ using different materials, and the benefits resulting from the more intensive use of parts/ materials occur in different parts of the value chain, there is no incentive to redesign a product
Policy and regulatory	- Subsidy schemes – e.g. the Random Depreciation of Environmental Investments (VAMIL); reduced rates of VAT - innovative leasing and rental contracts - More reactivity is needed by EU directives to accept new biobased products with different properties so that they can be accepted by consumers - The EU's WEEE directive should set targets for waste collection <u>based on the value of raw materials and not on weight</u> - Member states can even decide to hold producers responsible for processing waste generated by their products	- The rules and regulations for plastics vary for each type of plastic, complicating the recycling of plastics
Cultural and consumer/ business acceptance	- Try to develop substitution of a material/ product/ service in the long-term, and not simply when there are supply shortfalls of the original - The concept of a circular economy has to be introduced into education - Develop the use of services instead of ownership - A harmonious discourse is necessary: A call to consume more and a simultaneous call to promote services that could have a negative impact on consumption will create a disjointed impression and will not lead to the desired unity of direction	- With many 'examples' of substitution the purpose has not been to improve raw material efficiency but to radically redesign products to provide a different/ better service, marketed on that basis – e.g. digital cameras have displaced film cameras - Acceptance that the circular economy means new ways of working and thinking that people will have had little or no experience with - Users can become dependent on the producers, because of long-term contracts for example - Consumers tend to look more at the price of a product and less at the entire lifecycle costs
Technological, infrastructural and economical	- Ecodesign to avoid using combinations of materials - Including reusable parts in the design of products - Knowledge development is needed for biotic waste to be reused and transformed through biorefining (potatoes, maize, straw, potato haulm, draff, sugar beet) - Weaken the dominance of incineration plants in the processing of biotic and abiotic waste streams to encourage recycling/reuse - Increase the dissemination of	- Although reduction in the use of raw materials is positive, in the case of some products, economically viable recycling is no longer possible and has led to the suboptimal reuse of materials - Over the last decade consumer products have become considerably more complex, so that effective and efficient recovery is a massive challenge - Future market developments are highly uncertain (shifting geopolitical alignments, complexity of markets, volatility of raw material prices, rapid changes in technologies/ products): investing in

Type of barrier/ driver	Examples of drivers and strategies	Possible challenges/barriers
	knowledge about the development of new materials - Develop mobile phone apps to inform citizens about waste collection points - Develop incentives – e.g. DIFTAR, a system of differentiated tariffs where citizens are charged according to the amount and type of waste they generate - Frontrunners face additional costs because of uneven distribution of power/resources in the chain so it is difficult to establish a viable business: they should have priority over incentives - A study of the financial incentives should also focus on 'perverse' incentives that could potentially have a negative impact on circular business cases – e.g. An energy tax is only levied on fossil fuels, but not on products based on fossil raw materials	large-scale recycling is perceived as very risky - Over the last decade consumer products have become considerably more complex, so that effective and efficient recovery is a massive challenge - A substituted product does not necessarily helps to reduce pressure on the environment but lead to increases in energy consumption e.g. plasma display panels - Knowledge development for the design process will have to focus on the art of combining constantly evolving standardization with designs that still allow manufacturers to distinguish themselves from their competitors - Knowledge management is fragmented and rarely cuts across sectors - Many businesses are unaware of the exact origin or the composition of the raw materials they use - Many of the fastest-growing young businesses are in fields such as IT services, software, apps, webshops and gaming, but are all but absent from the heavy industry sector, which is extremely important for the development of a circular economy - Availability of products components for repair by independent operators is often blocked by businesses that have a monopoly on supplies of components or products

Impact assessment of circular economy initiatives in specific value chains and sectors (cost & benefit analysis)

The total value of the opportunities presented by the circular economy for the Dutch economy could amount to:

- **€7.3 billion** a year in market values (or 1.4% of today's GDP)
- Approximately **54,000 jobs**
- A reduction of **17,150 kt in CO_2 emissions**

- A reduction in land use of **2,180 km^2**
- Avoided use of fresh water of **0.7 billion m^3**
- Avoided use of raw materials of **100,400 kt** (more than 25% of the total imports of goods by weight in the Netherlands/ year)

The potential **effects** of more radical changes and business models that could help the move towards a circular economy are particularly **difficult to calculate**

The **negative economic effects of a transition** have been taken into account. A shift towards more recycling can result in **higher costs** in some cases, and a circular economy would also lead to **fewer new products being bought**

<u>The abiotic circular economy: products from the metal and electrical sectors</u>

A part is considered to be **more valuable** if it has been removed from the original product – e.g., a computer disc drive is worth more if it has been removed, cleaned and is ready for reuse.

The value of new products from the metal and electrical sectors that are sold on the Dutch market amounts to approximately €16.5 billion every year. The total value of the "circular feedback loops" (€3.3 billion) is only 20% of the new value. The most important contributions come from the repair and reuse of measuring equipment, followed by a broad group that includes computers, televisions and other household appliances. This is understandable in view of the depreciation in value that occurs, for example, when goods are reused (second-hand goods) or recycled.

Table 2.3. Value of the current circular economy for metal and electrical products (2010)

Products	Value of new products (€ million)	Repair, reuse of products and components (€ million)	Recycling value (€ million)	'Circular' value (€ million)
Light bulbs	482.8	0	-33.3	-33.3
Base metals	113.5	0	-5.1	-5.1
Air conditioners	73.9	16.9	9.9	26.7
Mobile telephones	898.3	165.6	-74.9	90.6
Electrical components	80.6	25.4	18.6	43.9
Metal products	2212.4	150.1	-33.4	116.7
Microwave ovens	122.0	9.2	34.7	43.9
Televisions	679.9	255.5	26.3	281.8
Electrical parts	135.8	61.0	35.3	96.3
Other consumer electronics	576.9	42.2	27.0	69.2
Home computers	4202.3	379.8	-114.2	265.6
Video and DVD players	1137.4	54.6	30.9	85.4
Refrigerators/freezers	248.1	13.3	54.8	68.1
Washing machines	384.9	147.5	66.9	214.5
Other domestic appliances	370.2	201.6	69.4	271.0
Electrical capacity	441.8	32.8	56.0	88.8
Measuring equipment	4324.1	1,391.8	206.6	1,598.4
Total	16,484.9	2,947.2	375.5	3,322.7

For the Netherlands, a more circular economy could help to avoid **CO_2 emissions** by **747 kt per year** (9.7% of the current annual CO_2 emissions produced by the metal and electrical sectors, not including the CO_2 emissions avoided in other countries due to reductions in raw materials use).

__**The biotic circular economy: waste streams as raw materials**__

A large proportion of biotic waste streams are **already being used as cattle feed** or raw materials for **biogas** or **second-generation biodiesel**.

Researchers are working to **develop novel applications** and processes that could generate a higher added value than existing uses, such as **biorefining**, **insect breeding**, the production of **C5 and C6 sugars**, **solid state fermentation**, and more efficient **biogas production processes**.

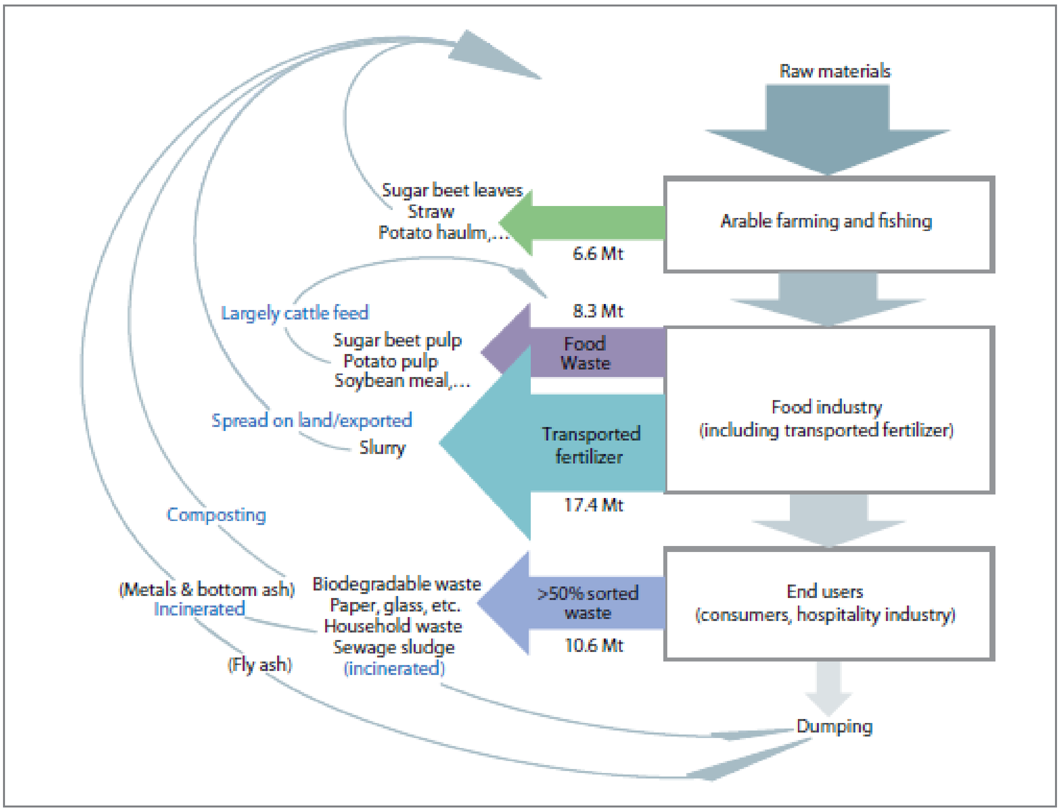


Figure 6 : Waste streams from the agro–food sector and their circular applications

In the most optimistic scenario, 34 biotic waste streams (sewage sludge, feather meal, cattle slurry, potato pulp, cocoa shells, fish waste, etc.) could generate **a net added value of €1 billion per year** for the Dutch economy:

- **50%** of this added value will be created by **increasing biogas production**,
- **42%** by applying **novel biorefining techniques**
- **8%** by increasing the volume of **household waste** being **sorted**

The land use avoided due to the use of biowaste would be of 2000 km^2; and in some cases, the new value of a waste stream that could be used more effectively in a circular economy would represent an immediate saving if that product is normally imported. Examples include RuBisCo protein extracted from sugar beet leaves (reducing imports of high-quality proteins), the production of biogas from animal slurry (eliminating imports of natural gas) or the production of ethanol from maize cobs (reducing imports of ethanol). In other cases, such as the biorefining of protein-rich draff, the potential benefits are not so clear. Indeed, draff is already used as cattle feed and so has helped to reduce imports of soya.

3 phases to develop a circular economy and achieve those results

<u>Phase 1: short term (0–3 years)</u>

- leasing and rental contracts for washing machines;
- subsidies such as the Environment Investment Allowance (MIA) or Random Depreciation of Environmental Investments (VAMIL), to lengthen product lifetimes;
- loan schemes such as Neemby, Floow21;
- increased recycling of LEDs due to their high value;
- reassessment of the WEEE directive;
- use of logistical knowledge of major ports;
- collective insurance to cover repaired goods/products with used parts;
- lift ban on stockpiling;
- rising prices of raw materials;
- use of reserve from collection contributions; and
- reduced rate of VAT on circular services

Phase 2: medium term — the period of Horizon 2020, the EU's Framework Programme for Research and Innovation (3–7 years)

- changing the location of incineration plants;
- 'assembly for disassembly' computers;
- changes in attitude towards possession;
- rising prices of raw materials (continuing incentive);
- conditions for the supply of parts incorporated into B2B contracts; and
- new technologies to intensify the use of biotic waste streams

Phase 3: long term – point on the horizon (>7 years)

- development of plastics that are designed for recycling;
- divestment of 'stranded assets' strategies;
- introduction of raw materials passports;
- rising prices of raw materials (continuing incentive);
- development of product service systems (PSS) for the most expensive metal and electrical product groups; and introduction of new technologies to intensify the use of biotic waste streams

D. Reinventing the wheel: a circular economy for resource security

Year	Type	Authors/ Organisation	Abstract

2011	Report	Hannah Hislop and Julie Hill, *Green Alliance*	The study concentrates on the role of **economic instruments** in promoting a more circular economy, a concept which has influenced economic policy in both China and Japan and which is gaining traction in many other countries. Three inputs crucial to society are examined: **metals, phosphorus and water**. The way we use them provides ample demonstration of our overwhelmingly 'linear' economy, with its current problems and future risks. This report makes the case for the **more circular use of resources**, as a way of avoiding at least some of the impacts of ever more extraction of natural resources, and to avoid the worst impacts of generating waste.

Definition of a circular economy

"Although circularity typically brings to mind the capture of material flows, relegating 'ultimate' waste to an ever-diminishing side-stream, the concept applies equally to the management of energy and water resources within a closed loop economy."

"**The circular economy represents a development strategy that maximises resource efficiency and minimises waste production, within the context of sustainable economic and social development**."

"Conservation is part and parcel of the ethos, since a resource efficient, closed loop economy protects the environment by minimising the release of potential pollutants and, by doing more with less, also reduces our draw on scarce natural capital. These resources include not just the obvious candidates (abiotic raw materials, fossil energy and water) but also extend to the carrying capacity of our terrestrial and aquatic ecosystems in the production of food and the delivery of other ecosystem services."

"There is no 'end' within a circular economy, but a reconnection to the top of the chain and to various activity nodes in between."

Circular economy instruments "can help to address current market failures which occur because the environmental costs, or externalities, associated with primary production and with waste treatment are not completely reflected in market prices."

Barriers and drivers

"Technical measures, such as discharge standards, recycling targets, energy efficiency benchmarks and leakage reduction targets, have been the most commonly used policy interventions. But **economic instruments**[136], particularly when applied further up the resource management chain, have received less attention. Correctly designed, and in tandem with technical measures, they send a strong signal to the market and its economic actors, catalysing the transformation to a more sustainable society."

"Market prices for resources are not necessarily reliable indicators of absolute scarcity, and are even less reliable indicators of environmental impacts. Economic instruments can create the price signals to move us towards a more circular economy, through encouraging the more efficient use of a resource, better product design to promote reuse or recycling, or a switch to a less damaging or scarce resource. They can also raise money to develop new ways of doing things."

[136] Economic instrument is any fiscal measure such as a tax, charge or subsidy, or removal of any of these, used to influence demand for a resource. Are included in this definition non-tax or subsidy measures such as deposit refund and trading schemes, where the price is set, either directly or indirectly, by legislation rather than the market.

Type of barrier/ driver	Examples of drivers (economic instruments)	Possible challenges/barriers
Policy and regulatory	1. **Metals:** a. **Product standards** that embody design for durability, recovery and recycling, with the addition of a product levy, to help give preference to such products in the market place as well as potentially funding the development of good recycling infrastructure. b. A **recovery reward** to drive higher rates of return to ensure that products can be reprocessed and valuable resources reclaimed. c. Better life cycle analysis to inform the choice of substitutes for some materials, which could also be promoted through a **product levy**. 2. **Phosphorus:** a. A range of incentives to **encourage the recovery of more secondary phosphate** from sewage and the use of high quality, secondary sources of phosphate in agriculture. b. Examination of a **phosphate levy**, not just because this might help to ensure careful use of the product, but also to raise money for phosphate recovery and recycling. 3. **Water:** a. **Universal metering**, more effective tariffs for consumers, and abstraction charging that reflects scarcity. b. **Increase awareness** of embedded water i**n the goods we buy**, whether from home or abroad, by promoting **water stewardship** and by encouraging greater transparency from companies. c. Make water stewardship part of an approach that sets environmental standards for products. ***Resource stewardship:*** *the development of the 'circular economy plus' where extraction of all raw materials, both renewable and non-renewable, as well as water and energy production, are achieved under a flexible but powerful ethos of stewardship by companies.*	

Priority value chains and sectors

Phosphorus

Phosphorus, in contrast to metals, **has received relatively little attention** as a raw material under threat. **Phosphate fertiliser underpins modern agriculture**, and there is **no substitute**. Feeding nine billion people by 2050 will be extremely difficult without adequate phosphate supply to farmers. Further increases in crops grown for biofuels will increase demand, as will per capita increases in phosphate demand, if diets continue to become more phosphate-intensive, i.e. comprise higher proportions of meat and dairy products.

While all farmers need phosphorus, a very small number of countries, in particular Morocco and Western Sahara and China, control the majority of the world's phosphate rock reserves. Both China and the US have imposed export restrictions in recent years. Agriculture currently depends on ready access to phosphate rock. While arguments rage about how long reserves might last, there is no consensus on how we might ultimately secure an orderly reduction in our extreme dependence on this non-renewable resource.

Considerable losses of phosphorus, between farm and plate, are not being addressed and **secondary sources of phosphate (manure, human sewage, food and crop residues) are treated as wastes rather than as valuable nutrient resources**. Worse, they are also allowed to pollute water courses, putting pressure on fragile aquatic environments.

Water

Water resources in England and Wales have been subject to much recent debate, with a tension between the long term need to charge to reflect current and future scarcity of water, and the more short term political need to avoid the perception of high price rises for consumers. The fact is that **water is too cheap to incentivise careful use**, and therefore too cheap to secure long term sustainability.

Metals

Although, in theory, metals will always be available and no-one can predict the extent of technological innovation in exploration and mining, it seems likely that, as reserves dwindle in future; these resources will come at increasing cost (both financial and environmental, as more energy and water are needed to process it).[137] On top of price volatility, there is strong concern about western economies' high dependence on a few special metals. These are traded in relatively small amounts but are crucial to some technologies, such as the magnets in electric cars and wind turbines, the screens of electronic devices such as iPads or the performance of photovoltaic cells. China is not the only country restricting exports of rare earth minerals.

The 1.3 billion mobile phones produced every year account for 12,000 tonnes of copper, 325 tonnes of silver, 31 tonnes of gold, and 12 tonnes of palladium.

[137] Copper mined at the beginning of the 20th century contained about 3% copper, but the current typical ore grade is now only about 0.3%.

E. Resilience in the Round - Seizing the growth opportunities of a circular economy

Year	Type	Authors/ Organisation	Abstract
2011	Report	Steve Wallace and Andrew Raingold, *Aldersgate Group*	Rather than reinventing the vision for a circular economy, the study but draws on the analysis of other studies on the subject – principally the ones of the Ellen MacArthur Foundation and McKinsey[138]. The report does not set out all the answers but outlines a number of questions that need to be addressed if the **UK** is to maximise the opportunity for growth and competitive advantage in a resource constrained world.

Definition of a circular economy

"The circular economy is a generic term for an industrial economy that, by design or intention, is restorative and eliminates waste."

"While traditional approaches to resource efficiency seek to decouple growth from resource use, the circular economy has a different relationship. It seeks to optimise all flows in the economy. By converting waste into 'food' for the next cycle and shifting from consumer to user for technical products, it potentially creates significant opportunities for profitable clean and healthy flows. It is aimed at creating abundance rather than scarcity while respecting limits. **Optimised systems in a circular economy are symbiotic** and restorative of social and natural capital.

Barriers and drivers

Type of barrier/ driver	Examples of drivers and strategies	Possible challenges/barriers
Institutional and organisational	Moving to valuation methods that properly take into account the economic value of environmental damages avoided or caused. Without these	

[138] McKinsey & Co (2011) – Resource Revolution: Meeting the world's energy, materials, food, and water needs

Type of barrier/ driver	Examples of drivers and strategies	Possible challenges/barriers
	market signals, the transition to a circular economy could be delayed by not making visible the true cost of many of our resources.	
Cultural and consumer acceptance		While there has been a discernible societal shift towards access rather than ownership (such as leasing mobile phones and car clubs), consumer acceptance needs to grow significantly. In addition, there must be a realignment of cultural values and incentives – particularly in the sales functions of businesses.
Policy and regulatory	**Product collection and reuse:** An infrastructure to support the efficient collection of products after use (reverse cycles) is an essential component for a circular economy. This can be heavily influenced by government policy (such as landfill tax), producer responsibility, new business models and take-back schemes. As resource scarcity leads to further increases in prices, it is likely that companies will not be paid for waste collection in the future but bid to take waste (resources) away from customers. **System changes:** The alignment of incentives would help to create stronger drivers for the adoption of circular economy approaches. These include industry standards and collaboration, access to finance and revision of the regulatory and fiscal framework.	**Cannibalisation:** There will be a number of winners and losers in the shift to a circular economy. As new business models develop and there is a shift from ownership to services, the result will be various "cannibalisation rates" where certain businesses lose market share to innovators. Vested interests will seek to maintain the status quo and be resistant to change.
Technological, infrastructural and economical	Large companies and their tier one suppliers might be big enough, in their own right, to adopt the principles of a circular economy but the majority of companies are reliant on external providers to create closed loops. Recycling rates for many materials are still low and perhaps an opportunity exists to 'leap frog' the linear economy (such as investment in recycling and waste incineration plants) and move directly to the circular economy, with the associated higher added value. There may be a role for Government to stimulate this through support for regional infrastructure and for companies seeking to develop in this market.	

Impact assessment of circular economy initiatives in specific value chains and sectors (cost & benefit analysis)

There is a multi-billion pound opportunity in the massive amount of valuable metals lost because of how we deal with products people no longer want.[139]

[139] Defra Press Office (16th March 2012) – Golden business opportunity hidden in consumer goods.

No case studies are developed.

F. A Global Redesign? Shaping the Circular Economy

Year	Type	Authors/ Organisation	Abstract
2012	Report	Chatham House	This paper develops **a common understanding of the definition** of CE and its key components, as the term is applied inconsistently by governments and companies, in order to help to lay the groundwork for wider take-up of the concept, encourage cooperation and avoid confusion. It explores the **potential of a circular economy** (CE) as a model for industrial organization that will help de-link rising prosperity from growth in resource consumption. There are three sections : - The first tackles the **redesign of industrial systems** at the system level, and particularly the role of heavy industries. - The second covers the principle of 'cradle to cradle' production, focusing on the need to **redesign products**. - The third considers how **changing patterns of consumer behaviour** might help determine future resource pathways.

Definition of a circular economy

"A 'circular economy' (CE) is an approach that would transform the function of resources in the economy. Waste from factories would become a valuable input to another process – and products could be repaired, reused or upgraded instead of thrown away."

"Moving towards the CE will require a paradigm shift in the way things are made – putting sustainability and closed-loop thinking at the heart of business models and industrial organization."

In China, the CE is defined in legislation as a generic term for reducing, reusing and recycling activities conducted in the process of production, circulation and consumption. Other countries have generally not used CE terminology to date, but it is important to note that China's approach is partly derived from policies and approaches adopted in other countries, notably Germany and other European countries, as well as Japan.

In practice, scaling up the concept of a CE raises political economy questions that were not historically the focus of thinking in this arena and are only starting to be explored. For example, which types of firms, sectors and regions stand to gain from the shift to a circular economy? Crucially, what are the immediate opportunities for countries seeking to stimulate their economies in a time of crisis? And how can countries ensure that the circular economy remains open and competitive?

Barriers and drivers

Type of barrier/ driver	Examples of drivers and strategies	Possible challenges/barriers to implementation
Cultural and consumer acceptance	To reach the mass market, a product certification or labelling system may be needed, like those which have been introduced for energy and carbon.	Key barriers include the lack of standardization of methodologies applied in different countries, the cost of assessing resource consumption for individual firms, and the absence of a widely recognized, independent organization to award certification on resource efficiency or a CE.
Policy and regulatory	Fiscal measures: Pricing in the externalities associated with resources and encouragement of minimal resource use, waste and pollution. Incentives for owners to put materials back into circulation – e.g. land-value taxes, value-extracted taxes and 'recovery rewards'. Removal of distorting subsidies on resources, energy and land. End-of-life regulations: These are already applied in countries including the EU, Japan and South Korea, especially for consumer electronics, electrical equipment and vehicles. The focus should be on rates of remanufacturing and reuse. Just as important will be the removal of any unnecessary regulatory obstacles to the use of 'waste', remanufacturing and new business models. Public procurement: Obligations on public-sector agencies and government departments to purchase resource-efficient and cradle-to-cradle products. In many countries this is a powerful lever for creating markets for more sustainable goods and encouraging innovation.	Political obstacles to putting an appropriate price on resource use

Type of barrier/ driver	Examples of drivers and strategies	Possible challenges/barriers to implementation
	Public support for Innovation: Policy is crucial in setting the framework to encourage private-sector investments in innovation, for example in new materials or supply-chain resource tracking Addressing legal Frameworks: Review of the legal implications of company-to-company cooperation – e.g. anti-trust frameworks and data protection and security.	
Access to financing		High up-front costs: At the macro level, a successful CE would foster growth and reduce vulnerability to resource-price shocks. But in the short term, there will inevitably be significant up-front investment costs and risks for businesses – e.g. retooling machines, relocating whole factories, building new distribution and logistics arrangements, and retraining staff. Attempting to transform a company's core business model is a risky task in itself and a strong business case will be needed. Clear, strong and predicable policy frameworks will be crucial to encourage investment and experimentation.

Impact assessment of circular economy initiatives in specific value chains and sectors

Electronics

Philips has a target for 2012 that 30% of its revenue should come from green products. The next phase of its innovation programme aims to 'close the materials loop', with a target of doubling global collection, recycling amounts and recycled materials in products by 2015 compared with 2009.

Carpets

Desso is aiming to fully implement cradle-to-cradle processes by 2020. The company already processes old tiles, separating the yarn, which goes to one of its suppliers. This supplier has itself invested in a de-polymerization facility and then makes new yarn from the waste. For tiles that still include bitumen, that material is separated and goes into road repairs and cycle paths, or serves as raw material for the cement industry.

Construction

The industrial equipment provider Caterpillar has for 30 years offered remanufacturing for a range of industrial products from earth-moving machines to water pumps. The company claims that remanufacturing saved 59,000 tonnes of steel, 91 metric tonnes of cardboard and over 1,500 tonnes of wood products in 2010. End-of-life parts have a return rate of over 90%.[140]

Automobiles

Renault vehicles with the eco^2 mark are designed so that 95% of their mass can be recovered at end-of-life to be reused or recycled. In 2004, Ford introduced a concept car called the Model U that showed the opportunities for modular, layered design, simplified engineering processes and other techniques that help enable remanufacturing and repairs.

Clothing

Patagonia has established its 'common threads initiative'. The company promises to make durable products and to repair faults quickly but also enables customers to fix minor damage. Franz Koch, CEO of clothing manufacturer Puma, says that his company will be the first to bring to market training shoes, T-shirts and bags that are either compostable or recyclable.

Waste

Waste management companies Veolia Environment, SITA UK and the van Gansewinkel Groep have introduced strategies that aim to enhance source-separation of materials. TerraCycle, a company that organizes the collection of waste from households and 'upcycles' them into more valuable products, grew by over 100% per year since its inception in 2001 to $16 million revenue in 2010, the year in which it also started to turn a profit.

G. Analysis of the evolution of waste reduction and the scope of waste prevention

Year	Type	Authors/ Organisation	Abstract
2010	Report	European Commission DG Environment	The objective of this study is to define the scope of waste prevention, investigate the potential contribution of waste prevention to resource efficiency by analysing the current situation, ongoing trends in both waste generation and prevention, and forecasting future

[140] Caterpillar (2010), 'Sustainability Report' http://www.caterpillar.com/cda/files/2838620/7/2010SustainabilityReport.pdf .

			tendencies, and initiate work on waste prevention indicators by analysing the tools to measure waste prevention.

Definition of waste prevention

Waste prevention includes **measures taken before a substance, material or product has become waste**. It can take place at all steps of the material flow but is **most effective in the design phase**. Measures for waste prevention include:

- Reduction of the quantity of waste, including through the re-use of products or the extension of the life span of products
- Reduction of the adverse impacts of the generated waste on the environment and human health
- Reduction of the content of harmful substances in materials and products.

Waste prevention can **increase resource efficiency**, one of the main goals of circular economy. As our resources are decreasing and consumption and waste increase, waste prevention is becoming more and more important. This report does not focus on circular economy but addresses the notion of the '**3 Rs**' (reuse, reduce, recycle), which is one of the key objectives of a circular economy, and which *is* the definition of circular economy in China.

The effectiveness of prevention measures is very difficult to assess as it often adds up to "measuring what is not there".

Two strategies exist:

- **output indicators**: direct assessment such as the size/degree of participation on specific response actions (difficult to measure its impact on the environment)
- **outcome indicators**: indirect assessment of the results of the action on pressure and state (the link between the instrument and the result is hard to assess)

The report does not give quantitative results on the impact of these strategies on the environment however.

Waste prevention strategies across the supply chain

	Design	Extraction	Production	Distribution	Consumption	Waste	End-of-waste
Legal	• Product standards • Prevention targets • Green public procurement	• Technology standards • Product standards • Prevention targets	• Technology standards • Product standards • Prevention targets	• Prevention targets • Market entries	Prevention targets	• Prevention targets • Technology standards	Product standards (end-of-waste criteria)
Economic	• Positive/negative financial stimuli • Extended producer responsibility	Positive/negative financial stimuli	Positive/negative financial stimuli	• Extended producer responsibility • Positive/negative financial stimuli	Positive/negative financial stimuli	• Extended producer responsibility • Positive/negative financial stimuli	
Communication / other	• Labelling • Awareness raising/education • Voluntary agreements	• Awareness raising/ education • Voluntary agreements	• Awareness raising/ education • Voluntary agreements	• Awareness raising/ education • Voluntary agreements	• Labelling • Awareness raising/ education • Marketing • Voluntary agreements • Green public procurement	• Awareness raising/ education • Voluntary agreements	• Awarene raising/ educatio • Green public procurer nt • Marketir • Voluntar agreeme s
Technical	Ecodesign	Technology standards	• Reuse (through remanufacturing) • Technology standards	Reuse (of packaging)	Reuse (reuse shops etc.)	Reuse (of parts)	

High potential areas and strategies for waste prevention

		strategies											
		awareness & education	ecodesign	EPR	GPP	labelling / certification	marketing	positive/neg. financial stimuli	prevention targets	product standards	reuse	technology standards	voluntary agreements
material flows		1	2	3	4	5	6	7	8	9	10	11	12
mineral	1	7,77	5,59		7,85	4,13	8,28	8,24	6,15	8,48	8,28	7,88	7,15
wood	2	7,06	5,24		7,14	7,55	7,57	7,53	2,72	7,77	3,79	7,17	6,44
bio-waste	3	8,89			8,97	4,69	9,4	9,36	3,64	9,6		9	8,27
plastics	4	8,63	12	7,7	8,71	9,12	9,14	9,1	7,01	9,34		8,74	8,01
paper and cardboard	5	6,19	4,8	5,26	6,27	6,68	6,7	6,66	4,57	6,9		3,15	5,57
glass	6	6,34	4,88	5,41	6,42	6,83	6,85	6,81	4,72	7,05		3,23	5,72
metals	7	9,99	6,7	9,06	10,1	10,5	10,5	10,5	8,37	10,7		10,1	9,37
hazardous	8	10	13,4	4,55	10,1	5,26	5,27	10,5	4,2	10,7		10,1	9,4
household (MSW)	9	8,96						9,43	3,67				8,34

Figure 7 : Matrix for high potential areas for prevention

H. Business Resource Efficiency

Year	Type	Authors/ Organisation	Abstract
2009	Report	AEA	Consider the business support programmes that have been used in the past to help businesses improve their resource efficiency and establish the support needed in the future.

This report does not give a proper definition of circular economy, but focuses on the evaluation of public strategies supporting business programmes for resource efficiency, resource efficiency being one of the key objectives of circular economy models.

Context: main issues regarding past support programmes

- **Many businesses still perceive resource efficiency as a distraction from the core purpose of a business**. One of the main objectives of support programmes should be to make businesses realise that they can achieve their core objective better and more efficiently by adopting more sustainable practices.

- **More consistent messages on the challenge are needed**; a single 'language' would improve the communication of resource efficiency messages to businesses. Communication techniques used to transfer messages to businesses should ensure consistency of language and where possible be tailored to the sectors targeted.
- **SMEs and micro-businesses are less engaged with business resource efficiency**, partly because past support programmes more successfully reached larger businesses and because SMEs believe that they are too small to benefit. Future support programmes need to do more to 'reach out' to SMEs.
- **More quantitative data is needed to help businesses benchmark** where they are and where they need to be in terms of resource efficiency.
- **Certain types of businesses find resource efficiency particularly difficult**. Rural businesses, for example, are limited by infrastructure and a lack of access to waste management and recycling services. Although technology lists have helped to some extent, important equipment – such as waste balers – remain missing from these lists. Services that enable businesses to access this equipment more readily are needed. Regionally focused funding is also required. Local networks can provide valuable help for businesses in a particular region.
- **The prescriptive nature of product standards can limit innovation and improved resource efficiency.** By stipulating specific materials rather than the qualities and specifications the material should meet, manufacturers have little scope to trial more innovative materials.
- **The current economic situation provides a perfect opportunity for encouraging businesses to become more resource efficient.** The high cost savings that come hand in hand with better resource use is a considerable incentive for businesses to act. Support programmes need to concentrate on communicating this message, and should identify the best means of reaching all businesses. This need not be only direct communications; improved supply chain management and the use of intermediaries that have close relationships with small businesses (such as banks) were just two suggested communication routes.

Barriers and drivers

Regarding the main issues of past support programmes mentioned in the introduction, Government support should be:

- **Targeted:** Where it will have greatest impact;
- **Efficient:** Delivered to get best value for money;
- **Fit for purpose:** Meets national, regional and local challenges in a changing global economy

The study confirmed that all businesses are struggling with the credit crunch, and are having difficulty prioritising resource efficiency. However, the current economic situation presents an opportunity for encouraging businesses to improve their resource efficiency, in order to achieve the cost savings that go hand in hand with better resource use.

Further research is needed to investigate how well the business support programmes help business sectors that are recognised to be less able to engage with and act on resource efficiency messages. It appears that delivery bodies generally target 'quick win' business sectors rather than the 'hard-to-reach' sectors. Some of the potential categories of businesses that could be considered for further investigation could include:

- **Black and Minority Ethnic Businesses**
- **Small Businesses/Micro-enterprises**
- **Rural Businesses**
- **Women Entrepreneurs**

Type of barrier	Examples of drivers and strategies	Possible challenges/barriers
Institutional and organisational	• The number of programmes caused confusion and there were calls for more consistent messages and language on resource efficiency - Business Link will be used as a primary channel from now on • Communications should be tailored to the sectors targeted • More follow-ups are needed to monitor progress with businesses after support initiatives are provided • Limited funds make 1 to 1 support unsustainable so a new approach such as 'one-to-many' needs to be found • Regionally focused funding is required	
Cultural and business acceptance	• SMEs often believe that they are too small to benefit from efforts to improve business resource efficiency – given that they represent 99.9% of enterprises in the UK it is crucial to explore what else can be done to 'reach out' • Change the perception that resource efficiency is a distraction from the core purpose of a business and show it can help them achieve their core objective better and more efficiently • Convince businesses that environmental advisors have sufficient expertise to provide useful advice and have a good understanding of a business's processes by making advice relevant to the industry • Sustainable public procurement is increasingly moving up the priority list due to consumer and business community pressures	Other types of businesses such as those situated in more rural areas are also hard to reach There is a lack of knowledge on how they can meet the desired environmental policy requirements, how they can get support and on the importance to act on the subject
Policy and regulatory	• The carrot and stick approach should be drawn on to improve incentives to act through economic instruments and increased funding • Keeping track of their resource consumption should be mandatory for all businesses • Require better environmental standards in order to get loans	
Technological and infrastructural	• SMEs and sole traders have difficulties to keep up to speed with what is required due to a lack of funds for conferences - more information should be disseminated through platforms such as trade associations or similar organisations • Linking support programmes with financial institutions that collaborate with businesses in day-to-day operations so they could provide advice on resource efficiency and lessen the impact on businesses' bottom-lines • Measures should be put in place to help environmental champions share their experiences with other businesses	

Feedback on past strategies/policies

	What worked well with regard to encouraging business resource efficiency?	What didn't work well with regard to encouraging business resource efficiency?	What are the immediate obstacles for the near future?
POLICY TARGETS	Landfill Tax CO2 commitments (large firms only) Climate Change Levy EU Directives	Pre-treatment of waste regulations LA's recycling for businesses as well as domestic Some policies weren't relevant for SMEs	Making landfill tax more applicable to SMEs Lack of enforcement of legislation Mix of voluntary and mandatory measures CCL not rising! Making the true cost of waste more apparent
Support Programmes	Fast Track visits Supply chain work Envirowise helpline Existing local initiatives and networks e.g. the Resource Efficiency Clubs Envirowise/Business Link crossover Courtaulds Commitment NETREGs	Too many programmes Innovators and designers were not full engaged Form filling for funding ECAs Lack of follow-up on direct support Some local initiatives were under-utilised	Lack of 1:1 support Encouraging long-term behavioural change Lack of reliable data Targeting SMEs Matching top-down and bottom-up approaches
Business engagement	Support worked well for large businesses Engaging with local suppliers was successful	Lack of engagement with smaller businesses Rural and home-based businesses were not well served	Engaging all sectors and smaller businesses Infrastructure required (e.g. recycling centres) in order to enable small and rural businesses Finding a way to develop networks, e.g. for sharing vehicles or technology
Communication methods	NISP's continuous engagement Envirowise website Local advertising and awareness raising campaigns especially via radio Trade Magazines	Lack of dissemination about best practice Lack of information about green suppliers Over communication, e.g. mail shots	More awareness-raising is needed Need a champion –individuals who can promote resource efficiency

I. Economic Analysis of Resource Efficiency Policies

Year	Type	Authors/ Organisation	Abstract
2011	Report	COWI for DG Environment	The objective of this study is to identify policies that have successfully optimized the use of resources. These policies were subsequently assessed in terms of their potential in a European context with the ultimate goal of providing inspiration to ways of improving resource efficiency in Europe.

No definition of 'circular economy' is given in this study; however circular economy is a means to reduce resource consumption. Resource efficiency policies can therefore be considered as a lever to build a more circular economy, although it is not the only possible approach of circular economy.

Resource Efficiency Definition

Currently, the general impression is that European economic resources are used inefficiently, leading to reduced competiveness. There is a concern over **shortage of natural resource stocks**, the security of supply of energy and other materials. Inefficient use of resources and over-exploitation of renewable resources constitute long-term barriers to growth. Potential resource efficiency policies address avoidance and reduction in the harvesting/excavation of resources, the use of resources in the production process, the efficiency of the operation of products as well as the reuse and recycling of resources.

The 4 main economic sectors in the EU exerting direct pressure on the use of resources are: **agriculture, the electricity industry, transport services and some basic manufacturing industries** (refinery and chemical products, non-metallic mineral products, and basic metals). However, resource **savings potentials of up to 20%** are present in all sectors in the EU. The sectors representing the highest potential are **construction, chemicals, metals** and **food**.

Most countries have a much stronger focus on **energy efficiency policies** than on **resource efficiency policies**. Furthermore, a **knowledge gap** exists on the net economic benefits that emerge from launching resource efficiency policies.

Barriers and drivers

Type of barrier	Examples of drivers and strategies	Possible challenges/barriers
Institutional and organisational	• Voluntary Top ten – e.g. Market Pull for High Efficiency Products, Euro-Top ten Plus (2009-11) will be expanded to 16 countries and include 20 partners • 'Green Purchasing' for the electric appliances	

Type of barrier	Examples of drivers and strategies	Possible challenges/barriers
	sector	
Cultural and consumer acceptance	• Resource efficiency targets (sustainability strategy, road maps) – e.g. Fundamental Plan for Establishing a Sound Material-Cycle Society (2000), Japan; Sustainability Strategies of Member States, The National Eleventh Five-year Plan for Environmental Protection (2006-2010), China • Information Networks – e.g. Environmental Sustainability Knowledge Transfer Network, UK; Green Suppliers Network, US; Green Purchasing Network, Japan	
Policy and regulatory	• Resource taxes (ad quantum) – tax base is the physical amount of the resource extracted – e.g. Aggregates Tax, (implemented in 16 European countries); Mineral Oil Tax (implemented in almost all European countries); Peat (Latvia, Lithuania, Sweden) • Resource taxes (ad valorem) – percentage of the cost of extracted mineral raw materials • Tradable permits • Differentiated VAT rate (products, product groups, sectors) – e.g. in EU usually not implemented for resource efficiency reasons, apart from tax reduction schemes in Czech Republic from 1993 to 2003, Portugal since 2001, UK since 2000 • Subsidies – e.g. in the United States companies producing liquid biofuels receive direct subsidies for every gallon of ethanol produced • Dynamic standards / Top-runner to improve adaptation and information deficits and increase secondary material use – e.g. Top Runner program in Japan • Governmental loan programs – e.g. Recycling Market Development Revolving Loan Program, State of California, US	Negative aspects of taxes: • administrative costs, monitoring (if infrastructure is not given) • potential reduction of employment in raw materials industry • less effective in guaranteeing a given environmental outcome • resistant to change; tax breaks require active decision by lawmakers to eliminate them Has to be re-approved with each budget cycle
Technological and infrastructural	• Eco-innovation – e.g. Framework Programme Renewable Resources, Germany (€ 800 million fund), Resource Efficiency Science Programme, UK	

Types of corporate responses to resource efficiency policies

The type of response depends on the type of policy instruments applied, the significance of economic impact of policy and the company's technical and organisational capabilities to adjust to the market changes triggered by the policy.

Pay the additional costs	**Continue the existing production methods and pass on the costs of the policy to the customer. This does not increase resource efficiency. If competing companies are capable of adapting their production processes, this may entail a loss of competitiveness and hence of market shares.**
Substitute	Substituting to a new resource typically involves a higher cost to the company than the original resource.
Optimise the use of resources	Improved resource management or introduction of new technologies requires up-front investments.
Change product portfolio	Phase out the existing product portfolio in favour of producing new products, using other resources.

Policy examples and possible extension to EU scale

<u>Aggregate Levy (UK)</u>

Description	Economic Benefits / Results	Challenges	EU scale potential benefits
Centralized and quantum-tax by weight to address environmental impacts of extraction and transportation of construction materials to encourage the more efficient use of aggregates	• Reduced sales of virgin aggregates by 18 million tons (2001-5) • decrease in the extraction of aggregates (6 million tons in 2005)	• low elasticity of demand so levy burden passed on to purchasers of aggregates • Additional 1 million tons of recycled aggregates supplied due to the levy has "cost" EUR 488 of additional taxation	EUR 5,682.6 million in potential revenue (for EUR 2/ton)

PIUS-Check (North Rhine-Westphalia)

Description	Economic Benefits / Results	EU scale potential benefits
EFA initiative to promoting cleaner production methods in SMEs (metal processing, metal finishing, food processing industries) by offering a PIUS-Check where the relevant material flows and current level of production technology are analysed and recommendations are made	More than 500 PIUS-Checks since 2000, 216 led to implemented measures (new production equipment, organisational changes…)	• EUR 776 million, if the same % of SMEs accept the PIUS check • EUR 333,000 over 10 years for SMEs

National Industrial Symbiosis Programme (NISP) (UK)

Description	Economic Benefits / Results	EU scale potential benefits
Free (to business) advice and networking program at a regional level to identify resource exchanges between companies for sustainable resource management solutions	May 2010 – membership exceeded 13,400 companies with 40% involved in at least one synergy project	• public expenditure on the program would be EUR 250 million public expenditure would be EUR 250 million • business savings of EUR 1,400 million, additional sales of EUR 1,600 million

Aluminium beverage cans recycling policies (Belgium and Sweden)

Description	Economic Benefits / Results	Challenges	EU scale potential benefits
Sweden: Producers of canned beverage and importers of metal beverage cans are required to join an approved	• Recovery rate cans through Returpack's recovery system was 73 to 74% from 2007 to 2009 • Generated financial	• Without deposits from not returned beverage containers, the system would yield a deficit before	Annual economic benefit to operators of EUR 19.6 million

deposit-based recycling system with a target of 90%. Consumers pay a deposit for every can purchased of EUR 0.052	result: EUR 520/tonne of aluminium scrap • Average annual deposit not reclaimed by consumers: EUR 15.1 million	financial items and taxes of EUR 7 million • Considerable investments in infrastructure are necessary to develop this system	
<u>Belgium</u>: Belgian companies packaging or arranging for the packaging of products sold in Belgium are liable to collect used packaging material to achieve a recovery rate of 90% and recycling rate of 80%. Household metal packaging waste is collected in special-purpose waste containers	• The recycling rate reached 93% in 2008 • Total income from selling aluminium scrap from cans: EUR 1.727-2.591 million	• The income generated from selling the scrap depends heavily on the value of the aluminium scrap • The costs of improving the EU recycling systems depend on how collection/handling of used beverage cans are managed presently	Economic benefit in the magnitude of EUR 7.4-28 million

<u>Sustainable clothing roadmap/UK</u>

Description	Economic Benefits / Results	EU scale potential benefits
Voluntary clothing industry initiative involving over 300 companies in the clothing supply chain to reach an action plan for their product to improve sustainability performance	Impossible to obtain specific economic data from companies recycling old clothing and textiles	Unused resource of 2.6 million tonnes of textiles disposed of as waste of which at least 1.3 million tonnes could be recycled so a total of (1.3 million tonnes * EUR 43) EUR 55,487,000/year can be saved on landfill taxes in the EU

<u>Green supplier network (US)</u>

Description	Economic Benefits / Results	EU scale potential benefits
Collaborative program run by the industry, the US EPA and the US Department for Commerce's NIST MEP: work with large manufacturers to assist them in engaging their SME suppliers through low-cost technical reviews to increase productivity, reduce waste, and boost profitability	• 2010 - 162 company members of the GSN had completed a Technical Review • Participation cost per company: EUR 3,515 • Average annual savings per company: EUR 86,700 • Much of the cost of delivering the programme is accounted for by other public expenditure so it is difficult to assess accurately the cost effectiveness of the programme • GSN have found without top down pressure on supply chains, SMEs will not seek assistance	• The lack of an independent evaluation to quantify the achievements of the GSN makes it difficult to estimate how well the programme could be replicated across the EU • Very large supermarket chains were suggested for the EU

Water for the Future (Murray Darling Basin, Australia)

Description	Economic Benefits / Results	EU scale potential benefits
The two largest components of the initiative are dedicated to • **giving subsidies to infrastructure to improve water use efficiency off and on-farm (EUR 4.1 million)** • **purchase of water entitlements for land owners to receive a share of the consumptive pool within an area so they can respond to climate change (EUR 2.1 billion allocated by the government)**	• 766 giga litres of water entitlements worth over EUR 0.9 billion have been purchased • The agricultural loss in the production is compensated for by the sale of entitlements to the government worth over EUR 2.2 billion • Surplus of EUR 1.63 billion to the irrigation farmers	The policies would be most relevant in the southern parts of the EU: By combining the use of a water quota system and financial support for implementation of water efficiency measures, the total water saving potential for Bulgaria, Greece, Spain and Romania is estimated to 6,600 million m^3 annually

Food waste reduction (South Korea)

Description	Economic Benefits / Results	EU scale potential benefits
Part of a management plan, which contains different food waste reduction programmes **95% of animal fodder is imported but a better use of food waste could save expenses on grains and fodder materials imports**	• The food waste recycling rate went from 21.7% in 1998 to 92.2% in 2007 • 2008: 5,274,980 tonnes of food waste were at a price of EUR 581 million	• Internal production of animal feed / fodder to replace imports could save EUR 10,400 million/year for livestock holders • Figures are hard to estimate and depend on current use of food waste and the potential to reduce it

<u>Basic policy on promoting green purchasing and green purchasing network (GNP) (Japan)</u>

Description	Economic Benefits / Results	EU scale potential benefits
The goal is to reduce environmental impacts by buying eco-friendly goods and services with the public sector as the main target group: **• by considering environmental attributes** **• environmentally sound material cycle** **• Reduction of environmental impacts and greenhouse gases** **• Long-term use and appropriate disposal** **The mandatory requirements of public green procurement have made the Green Procurement Scheme effective**	• This In turn provides benefits to the companies: ❖ Increased resource efficiency which increases profitability ❖ Enhancing company image • The market size of environmental business in Japan is forecasted to be rapidly increasing from EUR 270 billion in 2000 to EUR 430 billion in 2010 and EUR 530 billion in 2020 • There are no figures showing the magnitude of resources saved by GPP policies for the various products groups	• Public purchasing corresponds to 17.6% of GDP in Japan and 16% in the EU • The magnitude of economic benefits to business that would emerge in a European context is highly uncertain

J. Economie circulaire, écologie industrielle, Eléments de réflexion à l'échelle de l'Ile-de-France

Year	Type	Authors/ Organisation	Abstract
2013	Report	Institut d'aménagement et d'urbanisme (IAU)	Establish a methodological and operational framework on the priorities that should be given and the action levers to set put so as to define and elaborate a regional circular economy strategy.

Definition of a circular economy

It is becoming increasingly more strategic for all economic actors to improve the management and efficiency of resources and to secure their long-term supply, by moving away from a linear supply chain. It is within that context that the concept of circular economy is emerging, inspired by the **functioning of natural ecosystems** where 'nothing is lost, everything is transformed'. Within an economic system**, it entails economic growth without increasing consumption of resources**, requiring **a deep transformation of the production chain and of consumption habits**.

Throughout the 20th century, the world's consumption in fossil fuels was multiplied by 12 and the volume extracted in 25 years has increased by 65%. The tension has increased in the raw materials' market, where prices have been increasing since 1990 and are volatile. A **decoupling of growth and resource consumption is necessary** to increase resource productivity. Indirect flows, comprising of imported materials, should also be taken into account. France has stabilised its consumption but relies heavily on imports and 68% of the resources it needs are non-renewable.

The Circular Economy economic model

On the other hand, the **production of waste is in constant increase** and is mainly produced by economic activities (91% of all waste in France in 2010), and mainly by construction and demolition within that sector. Since the 1990s there has been a general increase in recycling, creating more jobs, and the Ministry for Ecology, Sustainable Development and Energy estimated in 2010 that 64% of the waste in France was recovered. As the offer for raw materials decreases and demand increases, recycling is becoming indispensable. However, it is not enough and the creation of a **new economic model** that works in a **closed loop** is necessary to minimise material and energy losses.

This model is based on **4 main principles**:

- Businesses should apply the principles of eco-design to all their products: this means using as little non-renewable resources as possible, using renewable resources (at or below their rates of regeneration), increasing the life products, minimising the transformation of goods when refurbishing or reusing them, increasing the reuse potential of products, and facilitate, at the conception stage, the sorting and final recovery of products;

- Actors should cooperate along the whole supply chain of a product to optimise its life-cycle: requires a cross sector approach and a cooperation between actors not used to cooperate (e.g. between those who design products and those who recycle);
- Consumption patterns should change from buyer to user;
- Think in terms of territory for ecological industry principles, put into place synergies between businesses for economies of scale. The pioneer city of Kalundborg in Denmark gave the first example in the 1970s by networking and forming links between companies of the port. The idea was to create synergies between companies through the exchange of materials (raw or recycled) and energy, and/ or by sharing “support” services such as logistics, transport, and various services to employees. Such cooperation enables to reduce intermediaries, generates economies of scale and reduces transport costs induced in the production process.

Barriers and drivers

Even though it is present across the State’s services and directions, circular economy has not yet been presented as a strategic axis for development. Certain elements imply that this will be the case shortly however: an Institute for Circular Economy was created in February 2013 with the objective of producing a framework law on circular economy by 2017.

Type of barrier/ driver	Examples of drivers and strategies	Possible challenges/barriers
Institutional and organisational	• Creation of a mediation structure to encourage and sustain cooperation between businesses • Public instances and local authorities should be more or less involved to support projects • Support actors that incorporate recycled materials in their products	
Cultural and business /client acceptance	• Inform the public about successful synergies so as to bring awareness of this new businesses model • Make recycled products attractive to clients so they can actually close the loop by consuming them, via a purchasing charter for instance • Develop a culture of cooperation and trust between businesses so they can coordinate their strategies • Promote recycling and its benefits and encourage a ‘user’ instead of ‘buyer’ approach to consumption	
Policy and regulatory	• Modify regulations so that they encourage recycled materials usage in new products; shorten and simplify the process for authorisations; develop European regulations to develop an exit procedure from the waste status to encourage reuse	

Type of barrier/ driver	Examples of drivers and strategies	Possible challenges/barriers
Technological, infrastructural and economical	• Government support for innovation and development • Promote principles of eco-design through informational workshops and ongoing monitoring of new developments in different sectors • Development of new technologies for information and communication so that: economic actors are aware of the environmental impacts of their production processes at different scales; continuous information is available on offer and demand for energy and on the quantity of material that can be reintroduced into economic circuits • Analytical accounting of material flows and linked costs at a sub-national scale in 2014 • Recovery of currently exported waste to lessen the need for raw materials – it would cover 9% of current needs • Develop a good knowledge of the energy and material flows of an industrial sector or geographical area so as to optimize their use and see where they can be improved • Make symbiosis between businesses for waste recovery more economically attractive compared to sending all waste to landfill • Develop synergies between businesses for workers services, energy flows, infrastructure… • Encourage the development of new sectors for waste recovery (such as rare metals) • Ongoing surveillance strategy for supply chain risks to help manage regional resources • Financial support at a regional level to encourage ecological industry measures and make them permanent • Take symbiosis possibilities into account when developing a new area of economic activity • Create recycling platforms close to production sites (proximity principle) • The priority in terms of energy should be heat recovery because of the region's numerous heating networks before it starts developing renewable energies	That kind of knowledge is hard to access due to competition and privacy policies within business This new model based on interdependence is riskier economically for businesses

The Aube Industrial Ecology Club

Connects local economic actors thanks to a developed network and research expertise from the *Université Technologique de Troyes*. A computer platform was developed to systemize synergy opportunities research and to collect flows information for 50 businesses. Working groups were also created to encourage discussion and meetings between economic actors.

Yprema: SME working in deconstruction-demolition waste valuation

The enterprise receives clinkers from the household waste incineration factory SIETREM on the same bank of the Marne River via barges towed by horses. Clinkers are transformed to be recovered for road engineering. The water used by Yprema is reused by the SIETREM incinerator to cool the clinkers.

EAZ Jean Mermoz at La Courneuve

Ongoing study to identify flow, equipment or service synergies opportunities between the 200 enterprises on the site. 25 synergy possibilities have been identified and validated: sharing a truck wash station; sharing a storage area for products; pooling ice-control salt purchase; creation of a local fertilizer service; shared company canteen…

Equimeth project

Methanisation of horse waste in the area close to the Fontainebleau forest where there are numerous stables. 40 000 tons of organic waste is methanised every year instead of being transported, substituting fossil fuel (natural gas) by renewable energy (biomethane) and decreasing greenhouse gas emissions. The regions of Moret Seine and Loing support the project by making their green waste available so it can be economically viable.

Feasibility studies on 4 projects in Plaine de Versailles

The area is vulnerable in terms of water and energy independence so 4 projects have been suggested: recovery of the hot water coming from the sewage treatment plant of Villepreux by the Mezu farm and recovery of its mud for energy use (methanisation); developing a wood-energy sector to complete the energy needs of the wood boiler at Fontenay le Fleury; developing a heat network.

K. Going for Growth: A practical route to a Circular Economy

Year	Type	Authors/ Organisation	Abstract
2013	Report	Environmental Services Association UK	Gives a definition of circular economy by breaking down its different stages, highlights some of the barriers to it and offers solutions along the supply chain.

Definition of a circular economy

'In a "circular economy" rather than material being thrown away after use, it is reclaimed and reused or recycled as secondary raw materials for new products (or for organic waste – as soil nutrients), with energy being generated from any residual waste that cannot be recycled.'

A circular economy, where the UK increasingly re-uses and recycles the resources it already has, could help generate 50,000 new jobs with £10 billion investment (~EUR 12 billion), boosting GDP by £3 billion (~EUR 3.6 billion).

What would the value chain be like in a circular economy?

The Value Chain	The Vision	The Economic Benefits
DESIGN	80% of the environmental impact of products is determined at the design stage:[141] • They should be easily reused, dismantled and recycled (e.g. avoiding difficult to recycle composite materials) • designers can aim to use as much recycled material as possible	Between now and 2020, **140 million extra tons of waste** could be successfully captured, leading to **£1.4 billion** in extra recyclate revenues for the UK economy.
MANUFACTURING	• Recovery of materials is maximized and fed into production processes	Quick win strategies implementation could enable

[141] Cited in German Federal Environment Agency (2000) "How to do ecodesign: a guide for environmentally friendly and economically sound design"

The Value Chain	The Vision	The Economic Benefits
	• Some residual wastes are processed into fuels and used as energy • Maximization of resource efficiency, thereby minimizing waste production – e.g. **Unilever** factories opened in 2012 have been designed to create 50% less waste than the average of all Unilever factories operating in 2008 • Waste which is produced is then fed back to the waste and resources industry for processing and returned to production	a reduction of the raw materials needed by over **38 million tons** by 2020,[142] with potential savings to the economy of **£23 billion**[143]
RETAILING AND CONSUMPTION	• Waste flows from retailers are minimized and then captured for recovery (Organic material is collected separately to generate energy) – under the Courtauld agreement, retailers should cut food and packaging waste by 1.2million tons in Phase 1 (2005-10), and by a further 8.8% in the first two years of Phase 2 (2010-12) • Waste and resources industry to provide recycling infrastructure for retailers, so customers can return materials • Eco-labelling use and re-shaping of consumers' preferences	If all retailers matched the recycling performance of the best, then **2.5 million tons** of additional recyclate would be collected with an economic value of **£250 million**
WASTE COLLECTION	• Local authorities work in collaboration with their waste and resources contractors • Collection systems are better designed and investment in new technology enables the capture of new material streams from the household waste sector • Separate food waste collections allow investment in new processing infrastructure • residual material is diverted from landfill to energy recovery	If current local authority best practice was replicated across the UK it would lead to an **extra 5 million tons** of household recyclables being collected. This material could potentially have a value in the region of **£500 million**

[142] "Securing the future – the role of resource efficiency", WRAP, 2010
[143] "The further benefits of business resource efficiency", Oakdene Hollins, 2011

The Value Chain	The Vision	The Economic Benefits
	• Push up recycling rates of all waste producers • Energy recovery from residual material to provide electricity and heating	
RECYCLING AND REPROCESSING	• Use of multi-stream Material Recovery Facilities (MRFs) which operate under the MRF Code of Practice for recycling • Innovative machinery to sort materials – e.g. automated infrared sorting equipment in UK MRFs has a throughput of 6,500kg/hour • Less glass collected in fully co-mingled collections and most of what is collected in this way is sorted by advanced optical sorters to re-melt quality • Most food waste is sent to Anaerobic Digestion plants to be turned into biogas • Residual waste is sent for energy recovery	Optimizing recycling and reprocessing facilities could create **30,000 jobs** in the UK

Barriers and drivers

Type of barrier	Examples of drivers and strategies	Possible challenges/barriers
Institutional and organisational	**Separate food waste** collections to become widespread for households and businesses **Business parks**, Business Improvement Districts and other clusters of SMEs to facilitate collective long term contracts for recyclate collections	
Cultural and consumer acceptance	To engage with and **inform consumers, politicians and business** regarding the benefits of the circular economy and the need for future change	
Policy and regulatory	A **BIS Ministerial post** should be created to lead on Resource Efficiency across Government, linking the current emphasis on industrial policy with the material resources agenda **Material Recycling Facilities (MRF) Sampling**	**Recyclate markets are volatile** due to limited UK demand and the challenge of extracting new sources of saleable recyclate from waste streams: Waste feedstocks are heterogeneous and **changing consumption** and **production patterns** change waste stream composition

Type of barrier	Examples of drivers and strategies	Possible challenges/barriers
	proposals should be strengthened in line with ESA input to Defra so as to have robust data on the quality of material entering and leaving the plant EU to use powers within the **Eco Design Directive** to set recyclability requirements for selected products to help shape the design and investment decisions of manufacturers on the EU market Specifications for recycled products/content in **Government Buying Standards** (GBS) to be increased EU should consider adding products with high recycled content to the **list of VAT reduced goods** Development of **standard clauses in local authority collection contracts** to enable better allocation of recyclate price risk between partners	over time. This can be difficult to manage and makes it risky for investors
Technological and infrastructural	**Waste management companies** to contribute experts to **help designers** understand the practical impacts of design choices	**Demand for recycled content** in products made in the UK remains **limited** because of: • the decline of manufacturing • a focus on recycling rather than use of recycled content in new products • the public procurement standards are not specific enough on recycled products Many of the 'easy wins' in recycling have been taken: the potential recyclate in the waste stream's composition makes it harder to aggregate cost-effectively

Overall economic benefits

Thanks to these policy recommendations it is estimated that:

- **50,000** new jobs could be created
- **£10 billion** of new investment unlocked
- GDP boosted by **£3 billion**
- The balance of payments improved by **£20 billion** by 2020

L. New business models for a radical change in resource efficiency

Year	Type	Authors/ Organisation	Abstract
2013	Report	Uwe G. Schulte/ Environmental Innovation and Societal Transitions	The report gives a definition of circular economy and presents it as a business model to attain a radical change in resource efficiency.

Definition of a circular economy

'The concept of waste in nature does not exist; everything is an input to another process in the life cycle. It is on this model that the circular economy is built: a product is designed to create minimal waste by allowing it to be easily repaired, or the materials to be upgraded or reused. In the circular economy, value creation is built on longevity and new forms of consumption'.

The linear sequence of supply chains: Extraction → Transport for several more conversion/assembly steps → Consumption → Waste → disposal (by incineration or landfill), is wasteful and inefficient. It should be replaced by a circular model that maximizes the effective use of resources, where 'waste is "designed out" and consumed materials are seen as nutrients in interlinked usage cycles'.

The circular economy cuts through the existing concept of growth based on increasing resource-intensive activity. One can distinguish three categories of material resource consumption:

3. **Energy** (actually 'useful energy' or exergy), whether from the sun, from sub-terrestrial heat, wind, tides, nuclear fission, or fuel combustion.
4. **Biological materials** such as food and wood products that can be safely returned to the biosphere, where they act as nutrients.
5. **Excavated materials** like metals and hydrocarbon derivatives (e.g. plastics), which are not biodegradable and are based on finite resources.

The creation of a new business model

The strain on resources will force companies to find new ways of doing business. This **transition from a linear to a circular sequence** will lead to the emergence of a new business model 'that will ensure prosperity in spite of population growth and the demands it makes on finite resources'. The key principles of a circular business model are:

1. **Minimize waste in product and system design** by selecting adequate materials (e.g. fewer composite materials); design for disassembly to facilitate recycling; and strive as much as possible for standardization of solutions.
2. **Understand the "total ecosystem" of a business** and ensure this is reflected in the business model, for example, through higher transparency of the interactions between the various phases of the product life cycles; and strive toward better collection and cycling systems.
3. Maximize **flexibility through design**. This applies to product design for ease of repair and later modifications, as well as to product usage where different modules can be assembled in different ways to accommodate changing requirements without rendering a solution obsolete.
4. Use **renewable energy sources** instead of wasteful exploitation of mineral oil, gas or coal.
5. **Maximize energy (exergy) efficiency** by minimizing the total energy content of products or services.

Impacts and benefits

By applying circular design principles and creating the logistics capabilities for the reuse of materials, the **EU** alone could achieve more than **US$300 billion (EUR 245 billion) in cost**

savings from motor vehicles, machinery and equipment, electrical machinery, furniture, radio, TV, and communication optical equipment, office machinery and computers.[144]

Based on detailed product-level modeling, it is estimated that the circular economy would represent an **annual material cost-saving opportunity of US$340–380 billion (EUR 250-280 billion) per year at EU level** for the 'transition scenario'; and US$520–630 billion (EUR 380-470 billion) per year (or a recurring 3–3.9% of 2010 EU GDP) for the 'advanced scenario', all net of the materials used in the reverse-cycle processes'.[145]

Whilst there is still some confusion as to what needs to be changed and how it should be done, there is a growing acknowledgment that the old labor/capital theory does not take into account the importance of "**exergy**" (and work) as a third major means of production.[146] "Exergy" is the 'useful part' of energy, whether the energy comes from the sun, from sub-terrestrial heat, wind, tides, nuclear fission, or fuel combustion.

Barriers and drivers

Barrier	Examples of drivers and strategies	Possible challenges/barriers
Institutional and organisational	Need for **new financial models** implies a shift from quick returns on investment toward a constant stream of cash, with a need for major upfront financing for manufacturers Cost of ecosystem degradation (and necessary maintenance and repair) These costs could be passed on to those firms and industries that make use of the associated ecosystem services, which would accelerate the process Since 2000, commodity prices have started increasing instead of decreasing, which led to: • a much tighter "balance" between supply and demand, • a tightening of short-term availability • the creation of new business opportunities – e.g. a ton of discarded mobile phones can yield over 200 g of gold when a ton of ore from a gold mine produces only 5–10 g, giving the incentive for mining landfills for precious materials (urban	New businesses as **intermediaries** that own the material content and sell it back to the producer at the end of the life cycle e.g. Dutch company Turntoo

[144] McKinsey and Company, 2011
[145] Ellen Macarthur Foundation, 2012, p. 67
[146] Kuemmel, 2011

Barrier	Examples of drivers and strategies	Possible challenges/barriers
	mining)	
Cultural and consumer acceptance	Need to find **new ways of generating profit** for the model to flourish in the long-run **pay-per-use** instead of ownership • car share schemes • Michelin pay-for-use tires for truck fleets	**Anti-trust concerns** led firms to end such schemes in the past (e.g. Xerox and IBM formerly rented their machines)
Policy and regulatory	**Incentives** are needed to speed up the transition to a circular model - labor tax is a barrier to that Creating a **tax on non-renewable resource extraction**. This would: • create business opportunity and employment save costs on ecosystem services	
Technological and infrastructural	Lack of good **collection systems** – e.g. electronic waste in many countries is collected by scavengers and shipped to low-wage and environmentally unregulated parts of the world where only 25% of precious metals are recovered and the rest is incinerated in the open (leaching cyanide and nitric acid) Solutions for the food industry using **circular design principles**: • optimize protection whilst avoiding waste from food packaging • moving production of food closer to consumption better shelf management	Need for regulation – e.g. an integrated modern metal processing complex like Umicore in Hoboken, Belgium can recover up **to17 metals** with recovery efficiencies of **95%** or more Unavoidable 'waste' from food processing could be 'designed in' as nutrients to be returned to natural ecosystems

M. Dutch Logistics 2040, Designed to last

Year	Type	Authors/ Organisation	Abstract
2013	Report	Council for the Environment and Infrastructure	Explore the logistics improvements needed to develop a circular economy model, with a focus on the high-tech, chemicals and agrifood sectors

Definition of a Circular Economy

The population is growing, consumption and waste are increasing and resources are become scarcer. According to the sectors **high-tech, chemicals and agrifood**, a circular economy offers a potential solution to this discrepancy. Companies in all sectors should adopt business models in which they **remain responsible for their products** throughout their entire lifecycles across the value chain: product design, production techniques, packaging and transport, recycling, etc. The **spatial clustering** of collaborating companies is highly important as it makes the interconnecting of links in the supply chain and the exchange of residuals between links easier.

The important role of Logistics

The transition to the circular economy has implications for logistics flows at global, national and local levels. Logistics is primarily a matter of organising, planning, managing and handling cargo flows, from their development and purchasing via production and distribution to the end user, including return flows and supply chain management in general. At the global level, the more control companies wish to exercise over the full lifecycle of a product, the more attractive it becomes to **operate close to the customer** (near-sourcing). At the national level, the transit functions will change. At the local level, an **increase in transport movements** will occur due to the increase in near-sourcing and e-commerce, but also to an increase in service logistics and reverse logistics.

Increase in traffic movements

One of the main challenges in terms of logistics to achieve a circular economy model is the general increase in traffic movements.

Near-sourcing

In the past, labour costs resulted in a shift in production to low-wage countries, but nowadays there is a reverse phenomenon from outsourcing to near-sourcing because of:

- Consumer demands for products which are more and more customer-specific, so it is better for manufacturers to be close to their market;
- Rising transportation costs;
- Levelling production and labour costs in developed and emerging nations.

Online shopping

More and more consumers are shopping online and want to have their order delivered at home or pick it up at a pre-designated collection point instead of going on a weekly shopping trip.

Home care logistics

The government wants elderly and sick people to increasingly live at home for longer periods of time. As a result, care is not dispensed at one central location but at many different locations instead. Therefore, the number of traffic movements increases.

Drivers and barriers

Two types of barriers/ drivers are illustrated in the study:

1. Those related to the development of logistics flows in a circular economy (at international, national and local scales), and
2. Those related to circular economy in general.

Type of barrier	Examples of drivers and strategies	Possible challenges/barriers
Institutional and organisational	• Predictable travel times so that companies can use them as a starting point for their operations • Streamline transport flows and urban distribution (both B2B and B2C) - e.g. Green City Distribution, Binnenstadservice, Cargohopper, DHL - System solutions (partnership between retailers on the same street or by sector/product; cooperation between transport companies)	network design and management need to be improved and better interconnected so as to switch to a different mode of transport in the case of disruptions Policies between municipalities for transport need to be harmonized (loading times, weights and measures, etc.)
Cultural and business acceptance	Strengthen the knowledge infrastructure regarding the circular economy, both through the training of future knowledge workers and a knowledge centre of international esteem	
Policy and regulatory	• European standardization for the business concept of new products / packaging can have a stimulating effect for a company and prevent unfair competition – e.g. using the NLIP (raw materials passport) to indicate those used in a product • Set requirements as regards the reuse percentage of components and raw materials in new products • The setting of end-goals should be harmonized at the national level (CO_2, noise, movements) • Legislation should progress from prohibition-oriented (safety requirements, competition law, definition of waste) to effect-based control in order to stimulate innovation • Stimulate the implementation and acceptance of new technologies through tax measures which reward ‘good behaviour’ by consumers (e.g. driving style) and companies • Try to limit perverse incentives (incinerators that are too cheap, energy levy that decreases with consumption, subsidies, etc.)	Lack of standardization makes reuse difficult

Technological and infrastructural	• Incorporate logistical challenges such as urban distribution in local spatial plans • Encourage technological innovation as it represents half of the energy gains on the supply chain where limiting transport only accounts for 5% of benefits • Use environmentally friendly modes of transport across the supply chain • Shorten (international) supply chains	

Policy innovations in specific sectors

The High Tech sector: move from product to service

Type of barrier/ driver	Examples of drivers and strategies	Possible challenges/barriers
Cultural and consumer acceptance	Encourage a move from product to service for consumers – e.g. thrift stores, Markplaats, Lenovo, LETS circles	Consumer arguments for convenience and status to defend ownership
Technological, infrastructural and economical	• Creation of 'repair cafés' where residents take their broken goods to repair them with the assistance of experts • Invest in 3D printing as a key technology and determine which components are most suitable to it • Develop 'urban mining': recovery of scarce resources from domestic waste and sewage	

The Chemical industry: move from stand-alone to networks

Type of barrier/ driver	Examples of drivers and strategies	Possible challenges/barriers
Technological, infrastructural and economical	• Make the supply chain as transparent as possible, as this will allow it to be organised more efficiently • Encourage chemical leasing, where the focus is not on selling as much volume as possible, but on ensuring the product is optimally efficient and effective by providing technical information – e.g. a trial in Austria led to a reduction in costs of 15% on raw materials used and of 1/3 in the amount of solvent used per car	Bulk chemicals: this subsector is vulnerable to economic balances of power and the market is consequently not transparent Chemical leasing is usually not the core business so is often not organized efficiently

Agrifood sector: move from retail to consumers as pivot in the chain

Type of barrier/ driver	Examples of drivers and strategies	Possible challenges/barriers
Institutional and organisational	• Reuse grain residues as food for fish farmers or livestock companies • Collect household food waste to transform into biogas or nutrients for agriculture – e.g. added value of 1.5 billion USD in the UK	Some important challenges to limit waste are cost-margin distribution issues, the right incentives, transparency of the supply chain and control
Cultural and consumer acceptance	• Develop consumer knowledge on origins and perishability; There is confusion between 'Best before' (BB) and 'Use by' (UB) labels for instance - e.g. GS1 DataBar (informational barcode about the shelf life of a product)	
Technological, infrastructural and economical	• Logistics service providers: invest in tools to optimise the information link between retailer and consumer to assess consumer needs more accurately - extend the supply chain to the consumer (planning, shopping, cooking and eating) and take it into consideration • Supplier and retailer: assume mandatory take-backs if a product remains unsold (magazines, bread, etc.) • Find innovative solutions to prevent food waste in supermarkets (600 million euros/ years' worth) – e.g. processing fruit and vegetables which are close to their expiry date into juice and soup instead of throwing them away ('Too Good to Waste')	

N. Évolution du statut de déchet : une contribution à l'économie circulaire ?

Year	Type	Authors/ Organisation	Abstract
2013	Report *(available only in French)*	Droit de l'environnement, n° 218	Allowing waste to be considered as resources, the evolution of waste status allows recycling schemes to contribute to the development of a more circular economic model. Keeping the status of waste for a recycled product, instead of the status of by-product, can be a barrier to

			circular economy.

Definition of a circular economy

Circular economy breaks with the traditional pattern of linear production, which goes from the production of a product to its destruction, and replaces it by a "closed loop" approach, where the creation of positive value is sought at each stage, avoiding the waste of resources and ensuring customer satisfaction.

A circular economy therefore requires an efficient use of resources and the recovery of used products, to transform them into secondary raw materials. As such, waste management is an essential component of circular economy.

However, the waste status influences the economic and legal conditions for the establishment of a European recycling society, required by the Directive 2008/98/EC.

Barriers and drivers

End-of-waste criteria specify when certain waste ceases to be waste and obtain a status of a product (or a secondary raw material). The barrier to a circular economy mentioned in this short report is the status of waste for a product that could easily be considered as a secondary raw material.

According to Article 6 (1) and (2) of the Waste Framework Directive 2008/98/EC, certain specified waste shall cease to be waste when it has undergone a recovery (including recycling) operation and complies with specific criteria to be developed in line with certain legal conditions, in particular:

- The substance or object is commonly used for specific purposes; there is an existing market or demand for the substance or object;
- The use is lawful (substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products);
- The use will not lead to overall adverse environmental or human health impacts.

The criteria have been laid down for iron, steel and aluminium scrap (2011), and, more recently, for glass cullet (2013). Next waste streams to be addressed include copper scrap metal, recovered paper, plastics and biodegradable waste / compost. Further studies are being conducted on biodegradable waste/compost and plastic. The end-of-waste criteria allow precious natural resources to come back into the economy by facilitating and promoting the recycling in the EU.

Barriers

However, **Member States may each adopt national criteria for end-of-waste status, regardless of criteria established by the European Commission** or the Council.

In a country like France for instance, the decree of the 2nd of August 2012 on the principles of the quality management system required to transform waste into products requires the ISO 9001 norm as a condition of giving the end-of-waste status to the recycled waste; yet this might be a burden for small and medium companies.

Another practical issue regarding the end-of-waste status is the implementation of the 'traceability principle'. More particularly, according to Article 6 of the French Ministerial Decree of 29 February 2012 fixing the contents of waste registers, French recyclers that turn waste into products must keep records of incoming and outgoing flows to "ensure that the traceability between the incoming waste and substances or objects have ceased to be waste." Since 2013, facilities that convert waste into products are exempt from the requirement of tracing the incoming waste. However, the issue remains for facilities that recycle waste *without* undergoing the process of end-of-waste status.

As national criteria only have a national scope, they cannot be imposed on those who did not recognize such criteria. The traceability principle is for example not applied the same way in all European countries (usually in the EU, controls must be achieved by the importing country), hampering relations between European economic actors.

Drivers

"Legal clarity" of regulations is therefore needed and can be achieved by **harmonising quality criteria across the whole of the EU**.

Furthermore, progress remains to be made regarding the status of a 'by-product' or the concept of 'reuse', to comply with the waste management hierarchy, which emphasizes reuse before recycling.

The legal status of by-products should help promote direct eco-industrial synergies in so far as by-products defined as such remain non-waste.

According to Article L. 541-4-2 of the Environmental Code, a material (substance) or object resulting from a production process – whose primary purpose is not the production of the substance or object – can be considered a by-product and not as waste if several conditions are met.

The study develops the idea that the evolution of the waste status can significantly contribute to the emergence of a circular economy model (yet no quantitative impact is estimated). Giving the end-of-waste status for various waste streams leads to the reintroduction of recycled materials in production chains, and refers to the concept of creating closed loops.

Annex 2: Prioritisation matrices

Table 1: Priority materials

	Material flow	Prioritised by…	Scarcity & dependence	Environmental impact	Potential savings	Key opportunities and challenges	Priority
Forestry & agricultural products	**Agricultural products & waste (including sewage sludge)**	• TNO 2013 • WEF & EMF 2014 • McKinsey Global Institute 2011	Possibly the most in-demand group of resources in the future (EMF, 2013)	High (especially food flows) (land use + high levels of waste + impacts from wide-scale production and transportation)	• 34 biotic waste streams (incl. sewage sludge, potato pulp & fish waste) could generate a net added value of **EUR 1bn per year** for the Netherlands. (TNO, 2013) • Societal benefit in 2030 from resource productivity opportunities in food waste = **$252bn**; large-scale farm yields = **$266bn**; smallholder farm yields = **$143bn** globally (McKinsey Global Institute, 2011) • The amount spent on landfilling in the UK would fall by **$1.1bn per year** if the food fraction that is now in municipal solid waste were diverted to more useful purposes such as compost and energy (EMF, 2012).	+ Certain **emerging technologie**s could provide additional value and displace virgin materials intake (WEF & EMF 2014) + The areas of **food waste, large-scale farm yields and smallholder farm yields** are Identified as priority areas in terms of opportunities for improving resource productivity (McKinsey Global Institute, 2011) + In the area of **large-scale farm yield**s, a proportion of **resource productivity opportunities are readily achievable** (McKinsey Global Institute, 2011) However: - (food waste) feasibility of resource productivity opportunities range from **some challenge**s to **difficult** (McKinsey Global Institute, 2011) - (smallholder farm yields) resource productivity opportunities are **difficult** (McKinsey Global Institute, 2011)	Priority
	Wood & paper	• WEF & EMF 2014		High (e.g. impact on ecosystem services such as CO2 sequestration and biodiversity)	• Value lost due to quality loss and ink contamination during the reverse cycle for paper and cardboard is approx. **$32bn annually** globally (WEF & EMF 2014)	+ (Paper & cardboard) While there are already high collection rates, there is scope and a need to **improve the purity of recovered/recycled materials** (WEF & EMF 2014), including addressing the issue of ink contamination.	Priority

	Material flow	Prioritised by…	Scarcity & dependence	Environmental impact	Potential savings	Key opportunities and challenges	Priority
Minerals, chemicals and compounds	**Textiles**					+ 25% of clothing in Europe is currently collected at end-of-use (EMF2, 2013) However: - For high collection rates to be financially viable, each collection must include enough clothing that is of a suitable quality to be sold as is - this stream drives the profit for the waste textiles industry. (EMF 2, 2013)	
	Plastics	• Arcadis 2010 • WEF & EMF 2014		High (produces high volumes of durable waste)		+ **Highest potential for prevention** (EC 2010) + (PET) While there are already high collection rates, there is scope and a need to **improve the purity of recovered/recycled materials** (WEF & EMF 2014) + (Polymers, e.g. PP and PE) **Systematic reuse solutions need to be developed**. Current barriers include: **low collection rates**, **difficulty maintaining quality and purity** due to high fragmentation of materials, supply chains, separation and treatment technologies (WEF & EMF 2014)	Priority
	Metals	• Arcadis 2010 • EMF 2012 • Green Alliance 2011 • TNO 2013 • McKinsey Global Institute 2011 • WEF & EMF 2014	Economically critical and becoming rare (Green Alliance, 2011)	High (the iron/steel sector is the largest industrial emitter of CO2 (BIO, 2010))	• Global societal benefit in 2030 from resource productivity opportunities: iron and steel energy efficiency = **$145bn**; end-use steel efficiency = **$132bn** (McKinsey Global Institute, 2011)	+ **High potential for prevention** (EC 2010) + (Steel) While there are already high collection rates, there is **scope and a need to improve the purity of recovered/recycled materials** (WEF & EMF 2014) + **Iron and steel energy efficiency, and end-use steel efficiency** are identified as **priority areas in terms of opportunities for improving resource productivity** (McKinsey Global Institute, 2011) + **Iron and steel energy efficiency, and end-use steel efficiency** are areas where **a proportion of resource productivity opportunities are readily achievable** (McKinsey Global Institute, 2011) + European Commission DG ENTR (2014) highlights the following metals in particular as critical raw materials: **antimony, beryllium, chromium, cobalt, gallium, germanium, indium, magnesium, niobium, platinum group metals, rare earths, tungsten**. + Value is lost as many **metals leave the EU** for metal recovery and recycling purposes.	Priority

Material flow	Prioritised by…	Scarcity & dependence	Environmental impact	Potential savings	Key opportunities and challenges	Priority
Phosphorus	• Green Alliance 2011	Economically critical and becoming rare (Green Alliance 2011); A critical raw material (European Commission DG ENTR, 2014)	High		+ **Substitution** with alternative sources of nutrients (sewage, animal waste, and food waste) - these could be sufficient to cover fertiliser requirement (EMF, 2012). + **Agriculture** uses the largest share of phosphate rock extracted: 85-90% is used for fertiliser, 5-10% for animal feed, and the remaining 0-10% for detergents, pharmaceuticals, fire retardants & electronics (Green Alliance, 2011) However: **- In agriculture, use of mineral phosphorus may be largely optimised already** and so further reductions may be difficult; e.g. in the UK the amount of phosphate applied per hectare of crops and grass per year has reduced by >50% (Green Alliance, 2011)	Priority
Rock	• WEF & EMF 2014		Medium (environmental impact of extraction and transport, and large amounts of intert waste to landfill)		+ There is scope to reduce primary aggregate consumption by promoting the recovery and reuse of secondary (recycled) aggregates, as achieved for example in the UK.	
Glass & ceramics	• WEF & EMF 2014				+ (Glass) While there are already high collection rates, there is scope and a need to **improve the purity of recovered/recycled materials** (WEF & EMF, 2014)	
Fossil fuels	• Arcadis 2010 • McKinsey Global Institute 2011	Economically critical and demand forecast to grow (Chatham House, 2012)	High			

Material flow	Prioritised by…	Scarcity & dependence	Environmental impact	Potential savings	Key opportunities and challenges	Priority
Other chemicals and compounds	• RLI 2013 • Arcadis 2010		High, with cross-cutting implications for the recycled quality of paper, textiles and plastics, for example.	[See, for example, potential savings of wood & paper]	+ European Commission DG ENTR (2014) highlights the following in particular as critical raw materials: **borates, coking coal, fluorspar, magnesite, natural graphite, silicon metal** + A key cross-cutting challenge to address c**ontamination issue**s and recovery/removal of chemicals, inks, etc. to improve the quality of recycled materials such as packaging, paper, textiles etc.	

Table 2: Priority product sectors

Packaging	Food	Electronic & electrical equipment	Transport	Furniture	Buildings & construction	Apparel & fabrics	Cleaning & cosmetics	
Packaging incl. bottles	**Food** incl. production, distribution, consumption & waste	**Electronic & electrical equipment** incl. mobile phones, smartphones, home appliances such as washing machines, electrical tools such as power tools and machinery, office equipment	**Transport** incl. automotive	**Furniture**	**Buildings & construction** incl. materials, production & design	**Apparel & fabrics**	**Cleaning & cosmetics** incl. soaps, detergents, makeup, etc.	← Sector /product
Food, electronic & electrical, transport, furniture, apparel, cleaning & cosmetics	Packaging, transport, apparel & fabrics, cleaning & cosmetics	Construction, packaging, transport	Packaging, food, electronic & electrical, furniture, construction, apparel	Packaging, transport, fabrics	Electronic & electrical (machinery & tools, long-term lighting & energy-use design), transport	Packaging, transport, food	Packaging, transport, food	← Cross-linkages with other sectors and products
• Arcadis 2010 • EMF 2013	• COWI 2011 • EMF 2013	• COWI 2011 • TNO 2013 • Arcadis 2010 • EMF 2012	• COWI 2011 • EMF 2012 • McKinsey Global Institute 2011	• EMF 2012	• COWI 2011	• EMF 2013		← Prioritised by…
High (fast-moving consumer good, large-scale, high-waste)	High (land use + high levels of waste + impacts from wide-scale production and transportation)	High (end-of-life waste & lifetime energy use)	High (end-of-life waste & lifetime energy use)	High (waste)	High (lifespan & long-term efficiency consequences from use)	High (waste)	High	← Environmental impact (current)

Packaging	Food	Electronic & electrical equipment	Transport	Furniture	Buildings & construction	Apparel & fabrics	Cleaning & cosmetics	← Sector /product
• The fast-moving consumer goods sector (comprising packaging, food & beverages, and textiles) could yield material savings of **EUR 509bn per year** (approx. 20% of the consumer goods industry's total material input costs) (EMF 2013)	• The fast-moving consumer goods sector (comprising packaging, food & beverages, and textiles) could yield material savings of **EUR 509bn per year** (approx. 20% of the consumer goods industry's total material input costs) (EMF 2013) • **High proportion of EU TMR and high savings potentia**l (COWI 2011)	• **Cost of remanufacturing mobile phones could decrease by 50%** if returned by customers and easier to dissassemble (EMF 2012). With a 50% collection rate, EU material cost savings of **$1bn**. With 95% collection rate: **$2bn** in material costs and $**160m** in energy per year. • Material input cost savings could range from **EUR 350m - EUR 400m** per year for smartphones B2B (EMF 2012) • Increasing the length of cycle of washing machines from 2,000 to 10,000 cycles saves **36kg of steel and 0.5t of CO2e** per machine (EMF 2012) • Electronics have a **high proportion of EU TMR and high savings potentia**l (COWI 2011)	• A shift from recycling to refurbishing in light commercial vehicles could save **EUR 6.4b**n in material inputs, **EUR 140m** in energy costs, and reduce GHG emissions by **6.3m tonnes** (EMF 2012) • Global societal benefit in 2030 from increased resource efficiency from transport efficiency =**$138bn**; electric and hybrid vehicles = **$138bn**; road freight shift = **$108b**n (McKinsey Global Institute 2011)		• For construction materials: Economic savings from reduced environmental impact by expanding the UK aggregates levy = **EUR 1.7bn** (private sector) and **EUR 2.1bn** (public sector) • For building energy efficiency: Global societal benefit in 2030 from resource productivity opportunities = **$696bn** (McKinsey Global Institute 2011)	• The fast-moving consumer goods sector (comprising packaging, food & beverages, and textiles) could yield material savings of **EUR 509b**n per year (approx. 20% of the consumer goods industry's total material input costs) (EMF 2013) • Clothing collected and sorted can generate a gross profit of **$1,295 per tonne** in the UK (EMF 2013)		← Potential savings

Packaging	Food	Electronic & electrical equipment	Transport	Furniture	Buildings & construction	Apparel & fabrics	Cleaning & cosmetics	← Sector /product
- Already some instruments tackling this issue	+ The potential in the food sector lies in **improving handling and transport to limit waste** (COWI 2011)	+ Policies are needed to boost collection rates, and design for disassembly and refurbishment (EMF 2012) + Complex medium-lived product (repeat use, responsive to technical innovation): contain multiple parts with scope for disassembly and refurbishment (EMF 2012)	+ Collection rates for light commercial vehicles are already at 71%, but volumes could be shifted from recycling to refurbishing (EMF 2012) + Transport efficiency, electric and hybrid vehicles, and road freight shift are identified as priority areas in terms of opportunities for improving resource productivity (McKinsey Global Institute 2011) + Investment in green transport infrastructure (dedicated lanes for pedestrians and cyclists) can promote jobs (UN ECE) However: - In transport efficiency, electric and hybrid vehicles, and road freight shift: resource productivity opportunities face some feasibility challenges (McKinsey Global Institute 2011)		+ For building energy efficiency: Identified as a priority area in terms of opportunities for improving resource productivity (McKinsey Global Institute 2011) + For building energy efficiency: a proportion of opportunities are readily achievable (McKinsey Global Institute 2011)	+ 25% of clothing in Europe is currently collected at end-of-use (EMF, 2013) However: - For high collection rates to be financially viable, each collection must include enough clothing that is of a suitable quality to be sold as is - this stream drives the profit for the waste textiles industry. (EMF, 2013) - Low potential for circular business practices (product design, reverse logistics and feasibility), with a degree of opportunities already captured today. (EMF 2012)		← Key opportunities and challenges
Paper & cardboard Plastics Metals (aluminium, steel)	Food Phosphorus	Plastics Metals (steel, copper, aluminium, rare earths)	Plastics Metals (steel, aluminium)	Wood Plastics Metals (aluminium, steel)	Wood Metals (aluminium, steel)		Phosphorus	← Associated priority material flows
Priority	Priority	Priority	Priority	Priority	Priority			← Identified as a priority

Annex 3: Summary of discussions from experts' workshop

Policy Studies Institute

Summary of discussions at experts' workshop 'Towards a circular economy in the EU – Priorities and options to move forward'

8 May 2014

IEEP Office, Quai au Foin 55, 1000, Brussels

1. Introduction

An experts' workshop 'Towards a circular economy – Priorities and Options to move forward' was held on 8 May 2014 in Brussels. The workshop was attended by representatives from the European Commission, national governments, business, NGOs, academia and other organisations. The workshop was organised in the context of a scoping study being carried out by the Policy Studies Institute (PSI), Institute for European Environmental Policy (IEEP), BIO IS and Ecologic Institute for the European Commission (DG Environment) **on potential circular economy actions, priority sectors, materials and value chains**. This study seeks to provide an **initial scoping assessment** of potential priorities and policy options to support the transition to a circular economy in the EU, drawing on experience at Member State and other levels. The study is being carried out from November 2013 – June 2014.

An **experts' workshop** was organised in Brussels as part of the policy recommendations element of the study which is led by IEEP. The aim of the workshop was to obtain insights from policy-makers and stakeholders on potential priorities and policies for a circular economy, practical examples from experience, and where EU attention could most usefully be targeted. The draft findings of the study were presented and discussed at the workshop. Discussions were organised around different sessions and held under Chatham House Rules (see Annex for workshop agenda). This summary focuses on the key points raised during discussions in each session. This summary is the study team's interpretation of discussions and does not represent a commonly agreed position among participants. The results of the workshop will feed into the final report of the study which will be available in July 2014. Presentations from the workshop are available from the following link:
https://dl.dropboxusercontent.com/u/89942462/Presentations%20at%20circular%20economy%20workshop%20-%208%20May%202014.zip.

2. Opening session

The workshop was opened by Pavel Misiga (DG Environment) who recognised the circular economy as the **next stage in implementing the Resource Efficiency Roadmap and Flagship Initiative.** He noted that many of the 'low-hanging fruits' in terms of policy options in this area have to a large part been initiated and that the EU is entering a challenging phase which requires **more systemic changes** and micro-economic policies to stimulate behaviour change among producers, consumers and public authorities. He maintained that the transition does not require significant investment or fundamental changes in the way the market or society operates; rather there are several policies already in place and a lot of activity from which lessons can be learnt. He also noted the need to identify **opportunities** where there is greater potential for change and **priorities for action.** He briefly discussed the **Commission Communication on the circular economy** which will be published in the coming weeks and is expected to set out upcoming plans and identify priority areas (e.g. the need to revise product design to enable circularity, remanufacturing and recycling) which will require further work and analysis in the next two-three years. He stressed the role of the on-going study as a **first step in identifying opportunities and priorities for action on the circular economy** to ensure the EU moves towards a resource efficient and sustainable future.

This was followed by a short presentation by Patrick ten Brink (IEEP) which briefly **introduced the circular economy** and how this contrasts with today's **linear economy** which includes some circular aspects such as recycling, maintenance, composting etc., but requires action to increase circularity at all levels and take advantage of untapped opportunities. He also noted how with innovation today's 'high hanging fruits' can become tomorrow's 'low hanging fruits' and highlighted the need to keep in mind that the **transition can lead to winners and losers** as more goods are reused and repaired, fewer new goods will be bought, which implies a loss of income for certain product manufacturers, transporters and dealers, and opportunities for others (e.g. service providers, recycling companies etc.). He concluded by setting out the objectives of the study and the aim of the workshop.

3. Opportunities for the circular economy

Mathieu Hestin (BIO IS) gave a short presentation on **barriers and drivers of a circular economy** which set out the main findings of the literature review task of the study. Some of the main barriers highlighted in his presentation include the **lack of skills, know-how and investment** in circular design and production; **distorted incentives** which discourage circular consumption patterns (i.e. a lack of cheap spare parts which encourages the purchase of new products); insufficient **internalisation of externalities**; limited incentives for **sustainable public procurement** practices; **competing economic interests and non-alignment of power** (e.g. between producers and recyclers); **limited consumer acceptance of service oriented models**; consumer awareness and habits. Other barriers relate to current **infrastructure and technologies, policy incoherence** and **planned obsolescence**. He also briefly discussed policy drivers which can help overcome some barriers such as improvements to **general framework conditions** through the internalization of environmental externalities (e.g. implementation of producer responsibility principle); **incentivising circular product design** (e.g. through revisions to the eco-design directive or use of eco-labels); support for **networking and pilot programs**, **investments and innovation**.

This was followed by a presentation by Ton Bastein (TNO) on the **opportunities for the circular economy in the Netherlands** which set out the results of a recent study by TNO for the Dutch government. The study found that in the area of **bio-waste**, the Netherlands has already captured an equivalent of €3.5 billion from current 'recycling' and there is a potential further opportunity of about €1 billion (especially for biogas from pig and cattle slurry). In the **metal** sector the study found that around €3.3 billion could be gained and 200,000 jobs created through remanufacturing, re-use and recycling. These figures were extrapolated to provide an estimate of the potential benefits of the circular economy for the Dutch economy of €7.3 billion a year. These figures are considered a conservative and prudent estimate, and reflect the fact that there is already some circular economy action taking place in the Netherlands. Mr Bastein noted that while the focus of policy efforts to date has been on recycling, this should be the least preferred option and further efforts should be encouraged which focus on various **inner circles such as reuse, repair and remanufacturing.** These areas have significant untapped opportunities; however they are more difficult for policy-makers to address. In the Netherlands the current policy approach of the Ministry of Infrastructure and Environment through the VANG ('Van Afval Naar Grondstof'[147]) is being reviewed with plans to increase the focus on education, supporting frontrunners, and engaging actors in the value chain. Mr Bastein stressed the need to **review existing legislation** which was put in place to achieve certain objectives (e.g. encourage waste-to-energy), assess its relevance today and revise it accordingly, keeping in mind the availability of alternatives (e.g. to incineration). He also suggested that **potential priorities** could be identified by focusing on **major consumers** (i.e. buildings, food waste), **critical materials** (including rare earth minerals), existing **infrastructure and inner circles** (e.g. service systems such as Spotify, leasing systems such as bo-rent, return/reuse schemes such as Xerox etc.).

A number of points were raised during the **Q&A session**. One participant recommended highlighting the risks involved in staying in a linear economy as a way of incentivising action. It was also suggested that rather than talking about a completely linear or a completely circular economy, one should, both ideally and practically, aim for somewhere in between the two approaches. The need to **think beyond traditional policy silos** was also emphasised as was the role of **resource pricing** in stimulating behaviour change. It was noted that the appropriate **service model depends on the sector,** e.g. the manufacturing sector could use a leasing model, while a service model could be more suitable for the chemicals sector and the music industry. It was noted that **social norms and habits differ across sectors and actors**, e.g. farmers share certain types of equipment (e.g. combine harvester) and that **civil society driven initiatives** such as repair cafés are playing an increasingly important role. It was noted that **industrial symbiosis** offers significant opportunities and is being taken forward through various initiatives such as a new plan in Rotterdam harbour. One participant also pointed to industrial ecology as an interesting approach which goes beyond industrial symbiosis.

The issue of **different incentives of actors along a supply / value chain** was recognised as an important barrier to the circular economy (e.g. photocopy manufacturers/leasing companies and the paper recycling industry) and the **need for systemic change** was stressed, including the need for greater **supply-chain cooperation**. **Local authorities** were described as the 'invisible' part of the value chain and the potential adverse incentives they face were briefly discussed, e.g. preferring incineration or landfilling of waste to recycling. The **potential incoherence between waste and energy policies** was also highlighted, e.g. biological waste streams such as wood or paper waste being subsidised for the production of renewable energy over cascading use which may be higher up the waste hierarchy. The relationship with the **bio-economy** was also emphasised and on-going work by DG ENTR, DG AGRI, DG RTD and DG ENV to identify new value chains and markets in this area highlighted.

4. Priorities for the circular economy

The session was opened with a presentation by Martha Bicket (PSI) on the **proposed priority sectors, products and materials** identified by the study team. She briefly described the approach to the

[147] Which could be translated in English as 'from waste to resource'

prioritisation exercise in the study which seeks to identify areas with the greatest opportunities for circularity and where the EU could play a constructive role. The first wave of proposed priorities identified by the study team were presented and include: product packaging (including beverages), food and waste, telecommunications, home appliances, furniture, buildings and infrastructure, personal motor vehicles (e.g trucks and motorcycles) and industrial motor vehicles (e.g. ships, trains and airplanes). Other potential priorities identified include: fish and other products, sewage sludge, phosphorus (e.g. soap and detergents), oil, fats and lubricants, apparel and other textiles, office equipment, heating and cooling equipment.

The presentation was followed by a **roundtable discussion** on the proposed priorities. During the discussion participants raised a number of points which are summarised below. On the prioritisation exercise itself, the importance of taking into consideration **social fairness** (i.e. child labour) and **biodiversity** in the analysis was also discussed as was the **geographical scale** of the exercise (i.e. EU, global) and the extent to which **'game-changing technologies'** are taken into account (e.g. soaps and detergents are already designed to dissolve in water – how much scope is there to improve circularity with current technologies?). **Fish and seafood products** was highlighted as an area where there is potential for greater circularity in relation to consumption, energy, material use, which also links to the area of **oil, fats and lubricants.** It was noted that DG MARE is currently developing a strategy on sustainable fisheries, which includes energy-related aspects. **Photocopiers and other office equipment** were noted as another area which could yield important opportunities for pro-active design for remanufacturing. This is an area which is highlighted in the literature, however in some sectors opportunities for greater circularity have already been (or are being) explored. Opportunities for circularity in **heating and cooling equipment** and **professional power tools** were also raised by some participants.

The need for **systemic change** was emphasised and the need to take into account **impacts on the whole value chain reiterated**, e.g. a ban on the landfilling of plastics could lead to an increase in incineration. Thus, regulatory measures need to be complemented by correct economic incentives including the **price of a product or resource**. **Potential trade-offs or conflicts between different policy agendas**, bio-economy, resource efficiency and circular economy, was also noted, e.g. increasing the energy efficiency of certain products may lead to an increase in the amount of iron, gold and copper in electronic devices. The need to avoid tunnel vision of a sector or product only approach was reiterated, with the suggestion that certain **cross-cutting or horizontal priorities be identified, material flows be considered and cross-sectoral opportunities be exploited,** e.g plastics is relevant for different actors across the value chain including business to business, business to consumer, packaging etc.

The need to **link actors in the value chain** was also emphasised as some actors do not think about the lifecycle of their product or what happens to it at the end of life – such opportunities need to be better understood to **ensure circular thinking from the start**. It was also noted that a reflection is needed on the distribution of economic rewards along the value chain to ensure that both costs and benefits are allocated in a fair way. Participants noted that **voluntary approaches can work up to a certain point**, however after that it becomes too 'painful' and there is a need for policy intervention. It was suggested that there is a need for **policy action to help reduce marginal costs and ensure a fair allocation of costs between different players along the value chain** (e.g. costs of innovation); **support greater velocity** of the cycles (e.g. so products come back faster, people hoard less, transport times are reduced, i.e. local proximity over global chains, and circles are made more efficient) and ensure **greater purity** of the cycles. This links to issues of **transparency** including on the origin of products, resources and materials and has policy implications at different levels depending on the **geographic scope** of the circular economy.

5. Current and planned responses to support a circular economy

Mieke De Schoenmakere (Flemish Ministry of Environment) gave a presentation on the **current and planned initiatives on the circular economy in Belgium** at both the Federal and Regional level. She noted that the process was initiated during the Belgian Presidency of the EU in 2010 which had a key focus on sustainable materials management and resource efficiency. Numerous efforts are underway in Belgium. For example in the Brussels capital region, the focus is on sustainable buildings, sustainable food, waste and resources, water, several projects exploring the possibilities of the circular economy have already started. In Flanders, a Materials Programme[148] has been set up which engages government, business, scientific community and civil society, focusing on nine levers (sustainable design, smart cooperating, slim investments, better regulation, sustainable materials management in the construction sector, the chemical/plastics sector, metal industry, bio-based economy, new materials and techniques) and 45 actions. The Wallonia region has adopted a New Regional Development Strategy known as the 'Marshall Plan 2022' which *inter alia* promotes partnerships to increase efficiency through competitiveness and business clusters. The planned Federal Roadmap for the circular economy was also presented; a draft of the roadmap is expected to be presented at the end of May. A key challenge remains how to ensure connections between relevant actors and initiatives given the complexity and scale of the circular economy, making best use of policy windows (including results of the elections) to speed up the transition, and ensuring appropriate skills needed for matchmaking, valorisation, and project set-up.

This was followed by a presentation by Neil Fourie (Department for Environment, Food and Rural Affairs, UK) on a **circular economy pilot study in the UK** which was part of the REBUS (Re-Engineering Business for Sustainability) programme. This included research and identification of new approaches/ideas, seeding new ideas through commissioning, using action learning and assessment to operationalise ideas and working with policy businesses and civil society to roll-out the system. The pilot study presented is a product service system based around baby equipment. Some of the main barriers to implementation of the project were set out including consumer credit legislation, resource limitations of project partners, rivalry between potential partners and difficulty in recruiting participating consumers. These barriers were overcome through various actions including a 'chain of leasing' which minimises financial risk and investment in incentives for participating consumer. A number of new projects are currently under development.

This was followed by a presentation by Egbert Lox (Umicore) on Umicore's experience of **implementing a circular economy in practice.** A number of case studies were presented including one on jewellery where barriers could be overcome through **improved logistics, collection infrastructure and free trade.** Another case presented was on a metal smelter which faces challenges relating to **innovation** (relating to fatal metals such as mercury and arsenic, how to improve efficiency of extraction processes while ensuring low consumption of energy, water etc.), **collection and the export of cars outside the EU**, which leads to a loss of important materials (i.e. catalytic converters) and reduced efficiency in extraction processes where these take place in developing countries. The final case presented was of a new battery recycling pilot plant which is currently facing a problem of over-capacity, highlighting the need for greater **investment in collection infrastructure**, agreements with car companies on **take-back requirements** etc. Other potential barriers to a circular

[148] http://www.vlaamsmaterialenprogramma.be/

economy highlighted in the presentation include the costs of logistics and rules on transport safety (e.g. on batteries which have to be transported respecting strict criteria).

During the discussions which followed the presentations, participants raised a number of issues including the **different incentives between actors** in the value chain as some stages may not be profitable (e.g. dismantling batteries) while others are very profitable (e.g. extraction of metals). Participants also raised the issue of **transparency and labelling** including difficulties in certifying the sustainability of processes in third countries, which varies according to the resource/metal/mineral concerned (e.g. Dodd-Frank Act, 15 recognised sustainability schemes for biofuels etc.).

The issue of **free trade** in relation to the export of cars and other products (such as electronic waste) outside the EU was also discussed, with some participants pointing to the 'world loop initiative'[149] as an interesting example, while others highlighted the lack of inspections as a shortcoming in implementation of the ELV Directive. Participants also discussed the issue of free trade, with some arguing for **'fair trade'** which respects standards in processing and recycling in third countries and due investments in these countries to facilitate such activities. Other participants maintained that practices in certain third countries such as subsidies to industry, trade barriers, and lower environmental standards than the EU mean that international trade is not 'fair' and in some cases may lead or contribute to problems of overcapacity in the EU, e.g. in the recycling sector. It was thus suggested that the '**proximity principle'** could be considered to encourage greater local recycling etc., although this was a contested issue among participants.

How to ensure **coherence between different targets and policies** was also discussed, in particular between **waste and bioenergy policies** where some participants argued there is a need for a more comprehensive approach to biomass and biowaste (e.g. through a framework on biomass or biowaste) which ensures coherence with other policies and goes beyond the current focus on energy to explore other opportunities for cascading use, e.g. combined digestion and composting which requires subsidies and infrastructure. The 'bio-economy valley'[150] in Ghent was highlighted as an interesting example in this context.

6. The way forward – potential options

The roundtables were opened by a presentation from Sirini Withana (IEEP) on the **proposed policy options** developed by the study team. It was noted that as the study is a scoping assessment, the policy options will cover a range of areas, rather than focus on sector or product specific recommendations and will include a mix of approaches, structured across different actors, levels and timeframes. The proposed policy options identified by the study team can be clustered into three broad areas: **regulatory instruments** (e.g. targets, requirements, extended producer responsibilities-including warrantees/guarantees and take-back requirements, better implementation)**; other instruments** (e.g. taxes, charges, voluntary agreements, information tools etc. which can be implemented by actors at EU, national, regional and local level, the private sector and other actors); and **public investment** (e.g. for R&D, industrial symbiosis, infrastructure &

[149] http://worldloop.org/

[150] http://www.gbev.org/en

services, information, advice & networking services, skills & training, GPP etc.). The presentation was followed by three roundtables structured around these issues.

Roundtable I: The role of regulation in encouraging circularity

During the first roundtable, participants discussed how far **better implementation of existing legislation** can support a circular economy. It was noted that existing legislation has been designed to meet specific objectives (e.g. **current regulation is designed to drive recycling** rather than what type of recycling should be encouraged, i.e. up-cycling, as well as other stages in the circular economy such as reuse, remanufacture etc.); thus there is a need to **regularly review existing legislation to see if it is 'fit for purpose'** and use this as an opportunity to revise legislation to reflect current policy priorities. Some participants also stressed the need to identify and address **existing legislation which can act as barriers to a circular economy** such as the **VAT Directive** which limits the scope of applying reduced VAT rates to certain areas, e.g. in Belgium reduced VAT rates are applied on reused clothes etc.; the **Directive on guarantees** which includes a provision to extend guarantees to two years, **consumer protection legislation** including on claims (e.g. DG SANCO is developing guidance on green claims), and **market surveillance**. The **renewable energy Directive** was noted as another obstacle to the circular economy which has driven support for biomass to energy over support for biomass to chemicals/materials even though the latter has greater potential for circularity. It was noted that this legislation should be revised so that it does not support the direct feed of biomass into one segment but rather supports its cascading use.

The issue of **poor implementation** of existing legislation was also discussed, with participants noting that implementation varies **across Directives** (e.g. Landfill Directive, individual producer responsibility under WEEE, waste hierarchy etc.), **not only at Member State level** (e.g. southern and CEE countries where there is a need to improve implementation of basic waste legislation), but also **within countries at the regional level** (e.g. Catalonia and Andalucía in Spain or Trentino and Campania in Italy). Participants noted the Commission's bilateral efforts in this regard. Some participants also recommended **increasing the participation of local authorities** to support better implementation, e.g. by introducing bans or restrictions on certain waste streams at the local level as a way of improving rates of recycling, while others emphasised the need to **consider wider issues such as corruption** which undermine implementation of environmental legislation. Participants also pointed to the role of **Green Public Procurement** in incentivising action among public authorities and the **European Innovation Partnership (EIP) for raw materials** as an interesting approach to information sharing between public and private partners. It was noted that although improved implementation of the waste hierarchy is not a new issue, there is a need for a **systemic change and the involvement of different partners** in a supply/value chain, in order to reach a shared objective, e.g. the 'EPR club'[151] established by ACR+ was given as an example in this regard.

Participants discussed the **need for new or revised regulations**; with some calling for a revision of the **REACH Regulation** as current rules for providing information have a high cut-off point thus missing various materials which fall below this threshold. It was suggested that the Regulation provide clear definitions of recycled materials to help increase **transparency**, improve business-to-business communication and facilitate

[151] http://www.eprclub.eu/home

assessments of compliance. The mismatch between the **demand and supply side of recycling** was also discussed, with one participant arguing that many of the 'golden oldie' countries in Europe have a high capacity for recycling, however a lack of / incorrect incentives (e.g. for local authorities to take waste out of landfill) together with high levels of exports (e.g. to China) mean that these facilities are running below their full capacity. This could be addressed *inter alia* through the use of **landfill restrictions (or bans) for recyclable materials, coupled with strong legislation on energy recovery** (to avoid incineration), as well as requirements for the **quality of recycling, price incentives to drive municipalities to increase recycling** and greater **engagement of actors along the chain** who may not have an incentive to increase recycling, e.g. ink value producers, photocopy manufacturers and the paper recycling industry. The **interaction between different pieces of legislation** was also discussed, including the line between legislation on waste and on resources where some participants identified a significant barrier to the re-use of products or by-products is that in some cases EU legislation still considers these as waste and as such prevents their re-injection in the value chain.

The forthcoming review of the **eco-design and the energy labelling Directives** was highlighted as a potential opportunity to extend existing legislation beyond the area of energy, with some discussion on the pros and cons of merging the two Directives. Eco-labelling could play a role in fostering the recyclability of the products (e.g. important not to re-circulate chemicals into biomass, which locks cascades), while **revised eco-design requirements or principles** for certain products which take into consideration 'end-of-life' would help the development of circular practices. This could be complemented by **increased transparency** including on what materials are used in products and in waste collected for recycling. However, it was recognised that this would require a robust approach including appropriate standards (e.g. on recyclability requirements) to avoid distorting the market. Participants noted the need to integrate requirements on **defined recycled content** within the eco-design Directive, to support greater transparency. This could start with reporting obligations on defined recycled content of specific products and gradually move towards a system requiring a minimum per cent of defined recycling content of products according to the sector/product characteristics.

<u>Roundtable II: Other instruments to incentivise action towards a circular economy</u>

Participants discussed a number of other types of instruments which can play a role in the transition to a circular economy. Participants recognised that a number of **voluntary agreements** are already in place (e.g. World Business Forum, certain purchasing agreements, WRAP etc.), although these approaches have been selective and ad hoc to date. Some participants argued that these efforts are considered 'common sense' for a company's CSR and branding purposes, particularly for those innovative companies wanting to push the boundaries. Some participants suggested that this could be one of the favoured approaches among industry. It was noted how the post-2008 climate has been supportive of such approaches, given rising resource prices and efforts of relevant actors to raise awareness of the circular economy, including the Ellen MacArthur Foundation and the World Economic Forum. Some participants maintained that legislation may not be necessary for a circular economy as it **requires innovation** which cannot be regulated. Where legislation is needed, some participants argued for framework directive type approaches which allow flexibility in achieving set objectives. It was however noted that while competition can drive innovation, **innovation can also be encouraged through certain types of action,** e.g. through funding from public authorities.

Participants considered **fiscal measures** to be effective as they have a direct impact on businesses and can **incentivise action** towards more circularity. This could be particularly useful in cases where the value of the product or material does not initiate a spontaneous effort to encourage circularity. The importance of pricing was reiterated, with some participants stressing the need to increase the value/prices of materials (currently considered to be non-valuable) to change incentives and increase circularity. A recently published study by the ex'tax[152] initiative in the Netherlands proposes a €30 billion tax shift from labour to material extraction which can be seen as a way of changing incentives in the economy. The importance of changing incentives for consumers was also stressed, e.g. in France the Parliament is discussing changes to tax law to better reflect recyclability of products and the availability of cheap spare parts.

Participants also discussed the importance of **information and awareness raising** among both consumers and producers, e.g. TESCO has various internal policies which seek to raise awareness among their employees, the Mainstream project seeks to improve communication, WRAP information campaigns etc. Such efforts were seen as important, given difficulties in engaging consumers. Participants called for more training, new messaging (e.g. of the health benefits from a circular economy) and for **continuous repetitive communication** which is supported by governments, civil society and industry to ensure a **coherent and strong message**. It was noted that
In some cases despite availability of information, it remains difficult to engage certain actors. For example, despite the availability of guidance for SMEs on how to become more resource efficient, interest in this is often low and there is a need to reflect on how to raise SMEs' interest in this area. This could for example be achieved by focusing on related aspects that are important and can appeal to a wider audience such as business logic, consumer demand for healthy products, etc.

On the issue of **planned obsolescence**, participants recognised the difficulty in proving intentional obsolescence across different types of products (e.g. white goods and vehicles). In some cases design departments rely on this as a first step in their design concept (i.e. design new products to replace previous models). Some work has been done which could provide insights on this issue, e.g. 'products that last' work by CE Delft together with industry. This is linked to **consumer habits and norms**, e.g. some consumers may want to buy a new phone after a certain period of time. Given difficulties in addressing this issue, it was suggested that **leasing and service provision** could be further encouraged to support proactive maintenance and repair. Another suggestion was that manufacturers could be required to **provide information on the expected or intended lifetime of a product** (e.g. as already done for light bulbs etc.) and **consumer associations** could collect such information and communicate this to consumers. **Citizen-led initiatives such as repair cafes** can be considered a response to such issues and could be used to drive public campaigns that eventually lead to behaviour change among producers. **Extending warrantees** for certain types of products could also be considered, however it was noted that consumer efforts to repair products could lead to an invalidation of manufacturer warrantees. Participants also briefly discussed the importance of 3D printing and collaborative open-source design which could for example increase consumer access to spare parts, as well as the benefits of **cross-brand standardization,** e.g. with phone chargers, and **innovation**, e.g. to replace hardware and software of mobile phones.

Roundtable III: The role of public investment

[152] http://ex-tax.com/

On the issue of public investment, participants discussed the use of **public funds to raise awareness of circular economy opportunities** (e.g. TV documentaries aired in the UK which required designers to re-use parts of an old airplane to make other products) and to **develop skills and training among the young** which emphasises circularity (e.g. design awards in Flanders for students). One participant highlighted the need to **increase subsidies** in certain areas, e.g. biomass industry and **reduce subsidies** in others, e.g. fossil fuels. The need for **investment in R&D and innovation** (e.g. to support initiatives such as Phonebloks[153]) together with investment in **pilot projects** to prove things work and encourage market up-take was recognised. The role of **GPP** in this regard was also noted, including the possibility of having a 'recyclability requirement' for public procurement practices and tenders and encouraging pro-active repairs and maintenance in public procurement through **increased awareness.**

EU funding for **industrial symbiosis** was considered useful, particularly in helping to identify the appropriate partners at regional and national level. In this regard, participants stressed the need for **'facilitators' at regional/national level**, where Cohesion Policy funding (ERDF and INTERREG) could be used to set up a **node of catalysts across European regions which act as facilitators in connecting companies and other actors** including municipalities etc. to discuss how to move towards a circular economy, identify perceived barriers and how they can be overcome and practical steps to be taken. **European Innovation Partnerships** (EIPs) were noted as a helpful starting point.

Participants recognised that a lot of financing is currently flowing into waste-related infrastructure (e.g. in Scotland), however a number of problems remain including the **costs of running facilities and a lack of material flows**, reflecting *inter alia* mismatched incentives across the chain. Different mechanisms can be used to address such issues, e.g. in the Netherlands if the costs to local authorities of collecting waste exceed the price they receive for it, they are compensated through a special fund set up by industry. This mechanism has been in place for the past 20 years and has also been used twice. The need to **increase information and transparency** was also emphasised, e.g. feedback from recyclers to consumers on how much waste has been collected in their region and what it has been used for can help to encourage greater separation of waste. Participants also discussed how to better use **existing infrastructure and services to improve collection,** e.g. using the **postal service** to collect CDs, DVDs and VHS tapes (e.g. as is being trialled in Portugal and France), **reinventing public libraries as community centres** to encourage greater reuse and repair, learning from **best practices examples**, e.g. weekly pick-up at end of street which is less costly than door-to-door collection, particularly in rural areas as has been trailed in certain parts of Scotland.

In the final tour de table, participants raised a number of issues including: the importance of **indicators** to measure progress, balance between **a systemic view and a more local approach**, **consistency and predictability** in policies and public incentives across time and areas, the importance of **fiscal incentives**, the need to **share best practices** between policy makers, business including SMEs and consumers across different sectors (e.g. through the UNEP SCP clearing house), the **external dimension** (in terms of the level at which circularity takes place and inspiration for best practices), focus on circles on the **biological side**, support for **bottom-up** rather than top-down approaches, the need to scale up and accelerate what is already happening, encouraging **closer collaboration** between

[153] https://phonebloks.com/en/about

different actors, develop **skills** in repair, reuse etc., incentives for **circular R&D,** and greater **engagement of municipalities**.

7. Conclusions and next steps

In her **reflections on the day,** Imola Bedo (DG ENV) noted growing recognition of the importance of a circular economy and a common understanding of the main barriers faced. She noted that the **materials perspective** should be strengthened and **cross-cutting, horizontal issues** rather than a purely sector and/or product focused approach be considered in the study. She highlighted the need for **more knowledge** on a cross-sectoral basis to understand how and what different materials, by-products and resources can be used for. She highlighted the need to **think in terms of value chains** and a systems approach when designing products. In terms of the policy response, she recognised that we are starting from an existing base and there is a need for a **'light touch' approach** which **takes into account what exists** and explores potential revisions to **remove barriers**. Discussions showed that in some cases, however, stronger approaches might be necessary. She noted that the circular economy has implications for **policies in a number of different areas**, e.g. transport, finance, reporting etc. and cannot be considered in environmental terms alone. She also recognised that there is a **strong business case** for a circular economy and a lot of activity already underway, albeit in an ad hoc, chaotic way. Thus, rather than a top-down command and control approach, what is needed is a **'helping hand'** to support and accelerate these processes.

Workshop programme

Policy Studies Institute

Institute for European Environmental Policy

Towards a circular economy in the EU – Priorities and options to move forward

Experts' workshop

8 May 2014

IEEP office
Quai au Foin 55
1000 Brussels

9:30-10:00	**Arrival and coffee**
10:00-10:30	**Welcome and introduction** Welcome by Pavel Misiga, DG Environment Introduction to study and objectives of workshop by Patrick ten Brink, IEEP Tour de table
10:30-11:00	**Opportunities for the circular economy** **Overview of opportunities and barriers to the circular economy -** Mathieu Hestin, BIO IS [10 mins] **Opportunities for the circular economy in the Netherlands –** Ton Bastein, Netherlands Organisation for Applied Scientific Research (TNO) [10 mins] **Q&A**
11:00-11:45	**Priorities for the circular economy** **Proposed priority sectors, products and materials -** Martha Bicket, PSI [10 mins] **Roundtable discussion on proposed priorities** where accelerating the circular economy would be beneficial and where EU policy can play a role**:** - ***Sectors*** (e.g. transport, construction) - ***Products*** (e.g. electronics, home appliances, furniture) - ***Material flows*** (e.g. food and food waste, packaging, phosphorus) ***Q: Where are there particular opportunities for the circular***

	economy and where can the EU play a constructive role?
11:45-12:15	**Tea/coffee break**
12:15-13:15	**Current and planned responses to support a circular economy** - **Planned roadmap for a circular economy in Belgium** – Mieke De Schoenmakere, Flemish Ministry of Environment [10 mins] - **Circular economy pilot study in the UK** – Simon Johnson, UK Department for Environment, Food and Rural Affairs (Defra) [10 mins] - **Implementing a circular economy in practice –** Egbert Lox, Umicore [10 mins] **Q&A**
13:15-14:00	**Lunch**
14:00-15:30	**The way forward – potential options (I)** **Proposed EU policy options**– Sirini Withana, IEEP [10 mins] ***Roundtable I: The role of regulation in encouraging circularity*** ***Q:*** *How far can we progress through* ***better implementation*** *of existing regulation? Where is there a* ***need for new regulation*** *or* ***revisions to existing regulation****? What are* ***successful models in EU regulation****?* ***Roundtable II: Other instruments to incentivise action*** ***Q:*** *What* ***other instruments are needed*** *(e.g. taxes, voluntary agreements, labelling, information etc.)? What is the role of different actors in each area (i.e. EU, MS, private sector)?*
15:30-15:50	**Tea/coffee break**
15:50-16:30	**The way forward – potential options (II)** ***Roundtable III: The role of public investment*** ***Q:*** *Where should the* ***focus be*** *(e.g. innovation, industrial symbiosis, infrastructure & services, skills, green public procurement etc.)? What EU funding instruments can be particularly useful and why?*
16:30-17:00	**Conclusions and next steps** **Reflections on the day and next steps** by Imola Bedo (DG Environment) **Concluding remarks** by Patrick ten Brink (IEEP)

Annex 4: Best practice case studies

1. German Packaging EPR Schemes

1.1 Brief summary of the case

German packaging waste recycling rates are among the highest in the EU-27 with 72.7% in 2010, and total recovery rates of 97% in 2011 (GVM, 2013). These rates have been achieved by regulation based schemes using Producer Responsibility Organisations (PROs) to recover and recycle metals, glass, paper and plastics.

The design and form of implementation of these schemes has been a key factor in their results. The success of the schemes appears to come from: attention to incentives for all actors involved in the material cycle; as well as the creation and support of market structures that provide cost-effective recycling and recovery. The schemes also show the limits of incentives as tools for reducing the use of packaging.

1.2 Description of case and how it supports a circular economy

The German packaging waste schemes have evolved since the first introduction of a collective scheme for packaging in the early 1990s. They represent successful use of PROs to recover and recycle metals, glass, paper and plastics. The schemes have created incentives and the institutional framework for high rates of recycling and recovery of consumer packaging in Germany. They are based on Ordinances adopted under the Closed Substance Cycle Act ('Kreislaufwirtschaftsgesetz' as it is called since amendment in June 2012.) There are two PRO schemes:

- The **'dual system' covers packaging reaching "private end users".** Companies that put packaging on the market (containing their products) are obliged by the German Packaging Ordinance to participate in a PRO. They can choose to pay one of 10 PROs for collection, sorting and treatment of post-consumer packaging waste arising from their products. The companies pay fees to the PRO for the weight of packaging material they put on the market, with different fees depending on the material (e.g. 7.4 cents per kg for glass in 2011 and 129.6 cents per kg for plastic in 2011). These fees cover the full cost of the PROs. PROs contract municipal and private waste management firms for collection and sorting with contracts tendered every three years. The scheme operates thanks to a high degree of separation of waste by consumers.

- From 2003, a **deposit system for one-way beverage packaging** was introduced. Purchasers of beverages covered by the scheme pay retailers a fee of up to 25c for the packaging (e.g. the bottle). This is refunded by the retailers when the packaging is returned. The system is managed nationally. Consumers and retailers are effectively responsible for collection.

1.3 Drivers / enabling factors

The dual-system and deposit schemes work by facilitating collection and recycling along the material cycle:

- The dual-system incentivises consumers to sort and collect waste, though a combination of **cost savings for households and information campaigns**. Consumers can reduce their annual waste collection charges with a smaller volume of weekly general waste collection. The significant deposit (25c) value on bottles under the deposit scheme provides incentives to consumers and informal street collectors of bottles. In the initial phase information campaigns cost €250 million.

- Both systems oblige **parties from industry and the retail sector to be responsible** for 100% of the cost related to packaging recovery. This leads to clear responsibilities and has led to packaging recovery to be viewed as a business activity.

1.4 Barriers and how these were overcome

- The scheme was set up after **long-standing discussions** among industry and commerce actors. This fostered understanding of the needs and mechanisms for packaging waste compliance schemes. It also prompted early and significant investment in logistic and recycling infrastructure needed for operation.

- In 2004 for the first time, the contracts for collection and sorting were awarded by a three-year call for **tender procedure**. This shift (from previous 10 year contracts) is one factor which has led to a reduction in cost of the dual-scheme by 46% (between 2003 and 2011, BKartA 2012).

- Problems of **free riding** remain: Only about 50% of the material collected from households is registered with the dual-systems.

- When it was introduced, the beverage deposit decreased the volume of material collected in the dual system and **increased the amount of material of higher quality being recycled** (i.e. bottle-to-bottle recycling) by providing incentives for reuse of bottles, greater collection of bottles and facilitating better material sorting.

1.5 Main impacts (environmental, economic, social)

The Packaging Ordinance and associated policy triggered:

- a **reduction of the amount of packaging waste** generated from 194 kg/capita in 1991 to 167 kg/capita in 1997. In this period, the weight of packaging used was absolutely decoupled from GDP, but has since risen - relatively decoupled. After 20 years of GDP growth, in 2011, the weight of packaging waste was still 4% below the

1991 weight[154]. This did not come from a reduction in the use of packaging as had been hoped (e.g. the overall use of packaging increased from 2009 to 2011). Instead, weight reduction came from the development of more resource efficient (lighter) packaging.

- **material recovery rates increased** from 37% to 80% (from 1991 to 1997 and remained around 80% since) for materials covered by the scheme.

- in 2010, 90% of **paper and cardboard** packaging, 47% of **plastic packaging**, 93% of **metallic packaging** and 86% of **glass packaging** was recycled. All these figures exceeded Germany's targets under EU packaging legislation.

- **high consumer acceptance**, with high participation, which leads to high recycling volumes. due The cost for the consumer for the packaging recovery system approximates to €10 -11/year. Total dual system fees collected were €941 million total in 2011 (€11.5/person) and the cost per tonne collected and treated €160. This appears cheaper than many costs for collection and treatment of the alternative disposal route which would be into residual waste where residual waste fees were between €171 - €664/year/household (data for North-Rhine Westphalia, Waldermann 2008).

The high deposit amount of 25 cents for beverage packaging has provided **motivation** for high return rates (98%). The amount and quality of recycling of beverage packaging rose. However, this deposit was not a strong enough in all beverage segments to raise the share of re-usable packaging, although for beer it helped re-usable packaging increase from 68% to about 90%. For instance between 2004 and 2009 one-way packaging increased by 20% at the expense of re-usable packaging (GVM, 2009).

1.6 Any particular sensitivity to the specific needs of SMEs

No. Weak enforcement may either advantage, or disadvantage small firms putting packaging on the market (POM) (depending on whether they choose to pay for their packaging materials through the dual-system or not). It is estimated 25-30% of the POM material is not covered by compliance with a PRO. This is in part due to grey areas of definition of obliged packaging (sales packaging has to participate in a PRO, transport packaging does not), and in part to fraud by packaging manufacturers.

1.7 Potential for replicability / transferability and main lessons

Use of extended producer responsibility, involving producer responsibility organizations, is widespread in the EU, being **mandated under EPR legislation**.

[154] Amounts of packaging in 1991 approximately 7646 kilotonnes, about 6846 kilotonnes in 1996, and ca. 7368 kilotonnes in 2011 (source: GVM, 2013)

Deposit return schemes for beverages are **less common**. There are key lessons about the success factors in setting up PROs from the German packaging schemes which could improve implementation of PROs elsewhere in the future (s.3 and 4 above) - in particular: reduction of costs through competitive tendering in a well-developed waste-treatment market; provision of adequate collection and treatment infrastructure; explanatory information campaigns to assist consumer behavioural change; provision of adequate price incentives (i.e. high deposit fees) to motivate action.

1.8 Referencing

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2. Economic and Fiscal incentives in France

2.1 Brief summary of the case

France has put in place both economic and fiscal incentives to support the transition to a circular economy. An important economic incentive is related to **Extended Producer Responsibility** (EPR) where France was the first EU country to introduce the principle of modulating eco-fees to incentivise eco-design.

France is also developing or revising fiscal tools to create further incentives for eco-design, such as further revisions to the '**Taxe Générale sur les activités polluantes'** (General Tax on Polluting Activities) to internalise waste management costs and to encourage recycling instead of storing and incinerating waste; an **upstream tax** for products not covered by existing EPR schemes; an **incentive-based pricing policy** for waste collection and **tax reductions** for food donations.

The complementarity of economic and fiscal incentives ensures their efficiency to decrease raw materials usage and minimise waste production.

2.2 Description of case and how it supports a circular economy

One of the main economic incentives driving a circular economy in France is a system of **Extended Producer Responsibility** (EPR) which was introduced in French law in 1992 when it was applied to household packaging waste. Certain types of waste were a priority from the beginning: dangerous waste (e.g. batteries and accumulators) and waste that was rising in volume (e.g. packaging). There are currently 17 different EPR systems in place in France –the highest number in any country in the world. While some EPR systems are compulsory under French or EU legislation, others stem from voluntary initiatives among producers. Under the system producers can either manage waste from their products themselves or pay a fee to a Producer Responsibility Organisation (PRO) which is in charge of carrying out this responsibility on their behalf (similar to the EPR scheme in Germany – see separate case study).

An interesting specificity of French EPR schemes is that many of them have introduced a **mandatory 'modulation' of fees paid by producers to PROs** that take into account various eco-design related criteria. In addition to weight and number of items collected, some of the modulation criteria currently applied under the EPR schemes include: amount of recycled material used in the product, whether certain materials used interfere with the recycling process, other criteria (such as the absence of universal chargers for mobile phones which leads to a modulation of 100%, although the difference in price is ultimately minimal: €0.02). In some cases (e.g. packaging), a bonus is provided if actions to raise awareness about waste separate collection are undertaken. In addition, a draft law currently being discussed reflects on the possibility of extending the criteria for modulation to product lifetime guarantee and availability of spare parts.

Other fiscal incentives to encourage circular economy include:

- The **General Tax on Polluting Activities** (GTPA) which is paid by companies that sell products considered to pollute the environment. It is also a downstream tax for waste that is landfilled or incinerated and further penalises treatment types that are less efficient in terms of pollution or waste recovery. The original tax, enacted in 1999, covered the disposal of waste, atmospheric industrial pollution and air traffic noise. It was extended in 2000 to cover washing products and insecticide products for agricultural use, among others. A tax on waste storage was introduced in 2000 and a tax on incineration in 2009. Since 2014 the tax also applies to single use plastic bags (Withana et al., 2014).
- The Committee for Ecological Taxation is considering the application of an **upstream tax for products that are not currently covered by EPR systems** (and therefore not recycled) to discourage consumers from buying them and further encourage eco-design. The two possibilities currently under discussion are to limit the tax to products that generate high quantities of waste (disposable cutlery for instance) or apply the tax at a lower rate to a larger tax base, excluding products from the food and energy sectors;
- Another instrument that is under consideration is an **incentive-based pricing policy** for waste collection (Pay-As-You–Throw – PAYT scheme) as is already in place in a number of other European countries, primarily at municipal level (Withana et al., 2014). Under such a system, citizens will have to pay for waste collected with fees dependent on quantity. French authorities are considering extending this policy to 15 million inhabitants in 2020 and 24 million in 2025, to eventually generalise it to the whole territory;
- Concerning food waste, people making food donations are entitled to a **taxation reduction** of 60% of the given sum, limited to 0.5% of the pre-tax turnover.

The following paragraphs focus on the modulation of eco-fees in EPR schemes.

2.3 Drivers / enabling factors

EPR schemes in France include compulsory modulations in fees paid by producers that depend on specific criteria established by PROs. These modulations vary under the different schemes and are still being established in some schemes. As noted above, the modulations currently include consideration of recyclability and waste prevention criteria. In addition, a draft law currently being discussed reflects on the possibility of extending the criteria for modulation to product lifetime guarantee and availability of spare parts.

This modulation in fees enables PROs to encourage or discourage specific types of behaviour that relate to waste prevention such as eco-design, life-cycle assessment, toxicity levels, etc. As such, it gives an extra economic incentive to producers in their decision to design sustainable products.

2.4 Barriers and how these were overcome

Whilst EPR schemes have been in place in France since the early 1990s, its characteristics are still unfolding and certain aspects are problematic. In particular, there are a number of challenges in implementing the modulation of fees as set out below:

- It is difficult to obtain a consensus about the criteria for modulation of the fees as it will disadvantage/advantage some producers depending on how it is set. To help overcome this, public institutions could be more involved in the establishment of modulation criteria to ensure criteria are set at an appropriate level;
- Since modulations are currently not applied in other EU countries, this limits their incentivising effect. To prevent this loss of effect, it may also be effective to generalise the modulation practice to the whole of the European Union;
- Ecodesign modulation criteria for products such as WEEE are particularly difficult to determine as a product that is difficult to recycle can consume very little energy in the rest of its value chain, while an easily recyclable one might demand a lot of energy to be produced (a mercury lamp represents toxic waste and currently increases the modulation by 20%, even though it only demands a small amount of energy to be produced): it is sometimes difficult to optimise energy use when considering the end-of-life impacts. A solution is to extend the modulation criteria to the whole lifecycle of products to take into account impacts throughout the lifecycle of a product and include more externalities.
- Finally, incentives provided through the EPR schemes are inefficient because their price is high whilst eco-contributions only amount to a few cents per product. Consequently, it would be necessary to increase the value of modulations progressively so that they actually have an impact on the manufacturer's practices.

2.5 Main impacts (environmental, economic, social)

The introduction of modulation criteria under various EPR schemes in France are still quite recent, and it is difficult to assess their impacts. However, a few observations can be made.

- Between 2007 and 2012, 100 000 tons of household packaging were avoided according to Eco-Emballages. For certain members, contributing to Eco-Emballages can represent up to 4% of their turnover, which creates a real incentive to avoid maluses on their fees.

- For WEEE, there is currently no strong evidence of a positive impact of the modulation. The low amount of the fees (compared to the prices of such products) and the fact that it is an international market has limited the impact of the modulation.
- For graphic paper, a decrease in the average weight of advertising brochures has occurred: - 15 % in 6 years.

2.6 Any particular sensitivity to specific needs of SMEs

A disadvantage that is cited by SMEs in the context of EPR modulation which takes into account a product's entire lifecycle is the fact that carrying out a Life Cycle Assessment (LCA) is very expensive and should be made more accessible to them.

2.7 Potential for replicability / transferability and main lessons

EPR schemes are well developed in other European countries and would benefit from harmonisation across Member States. The French experience illustrates how these schemes could be improved to better support eco-design of products through the integration of modulated fees which take into account relevant criteria such as recyclability, product lifetime guarantees, availability of spare parts etc. An important lesson from the French experience is that modulating fees can strengthen incentives for eco-design provided the fees are set at an appropriate level and applied in a number of countries, including neighbouring countries to ensure waste is not exported for processing in countries which do not apply similar fee schemes.

Taxes on landfill and incineration, as well as PAYT systems, already exist or are being developed in several other EU countries (Withana et al., 2014), and where appropriately designed have had positive impacts on waste prevention and recycling (IEEP et al, 2014).The “upstream tax” on non-recyclable products, on the other hand, is an innovative tool, currently under discussion by French authorities, and could also be of potential interest to other countries considered further action in this area.

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3. Materials Programme in Flanders (Belgium)

3.1 Brief summary of the case

The Flanders' Materials Programme[155] was launched in June 2012. It followed the 2006 'Flanders in Action' plan[156] which aims to address thirteen large societal challenges, one of them being Sustainable Materials Management (SMM). In the Materials Programme, different stakeholders join forces and combine long-term vision development and experiments, policy-relevant research and concrete actions. This is done respectively within a transition network Plan C[157], Policy Research Centre for Sustainable Materials Management (SuMMa)[158], and Agenda 2020, an operational action plan with nine levers and 45 actions.

The Programme aims to establish a basis for a green circular economy with the lowest possible use of raw materials, energy and space, and the smallest possible impact on the environment in Flanders and elsewhere (Vlaamse Regering, 2012b). As the Materials Programme was launched only two years ago it is not yet possible to identify any specific impacts. Nonetheless, the Programme can be considered an interesting case of a regional approach to supporting the circular economy, through a strategic, overarching plan which has managed to engage 33 parties in the transition towards a circular economy including research institutes, industry, NGOs, and public authorities. Moreover, it uses an integrated approach across a number of different areas, involving concrete agreements with different parties, set objectives and indicative timeframes for action (*Ibid*.).

3.2 Description of case and how it supports a circular economy

The 2006 'Flanders in Action' socio-economic business plan aimed to improve the position of Flanders by concentrating on areas where the region has a comparative advantage. However, by 2010 it had become clear that the plan needed a policy approach that fitted its high ambitions, as involving business and civil society proved more difficult than expected. Therefore, the Flemish Government decided in July 2011 to strengthen the plan by introducing 13 transition management processes, one of which was focused on SMM. This resulted in June 2011 in a Round Table on SMM where 33 stakeholders signed a Declaration in which they agreed to work towards a Materials Pact and an operational plan on sustainable materials (Paredis and Block, 2013). The following year, the Flanders' Materials Programme was launched.

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[155] http://www.vlaamsmaterialenprogramma.be/

[156] www.vlaandereninactie.be/

[157] http://www.plan-c.eu/

[158] http://www.steunpuntsumma.be/

The Flanders' Materials Programme brings together government, business, knowledge institutions and civil society, through three mutually reinforcing pillars:

1. ***Long-term vision and experiments: 'Plan C'*** is a transition network which aims to accelerate breakthroughs in SMM. It functions as a platform which brings together different stakeholders to shape a long-term vision[159], activate a self-learning network around SMM, and support transition experiments[160].
2. ***Policy-relevant research: The Policy Research Centre for Sustainable Materials Management*** (SuMMa) investigates which economic, policy and social preconditions need to be fulfilled in order to realise the transition to a material-efficient circular economy. It involves five research clusters: system analysis, monitoring and evaluation, economic aspects, legal conditions, and multi-actor governance.
3. ***Action: Agenda 2020*** is a plan for the implementation of 45 concrete projects with active partners including research institutes, industry (e.g. a building confederation, a technological industry federation, the Belgian Federation for Chemistry and Life Sciences industries, the Federation of Environmental Companies), environmental NGOs, and public authorities (e.g. the Flemish Department for Economy, Science and Innovation), as well as a clear time schedule.

What makes the programme unique is that stakeholders are jointly responsible for parts of the programme. The programme includes nine levers as described below:

1. ***Promoting sustainable design in manufacturing*** and including this in education. Moreover, the lever includes minimum standards in European product directives regarding reusability, recyclability and the use of recycled materials. For priority product groups, the programme strives towards defining material criteria within the framework of the EU Ecodesign Directive.
2. ***Providing information and the right conditions for smart collaboration, and raising awareness*** (e.g. campaigns aimed at returning batteries). This lever also includes enlarging the existing networks of 'sharing economies'.
3. ***Encouraging smart investments***, including government investments in a green circular economy, and use of green fiscal measures. The Programme wants to promote a sustainable procurement policy among businesses by adding a materials component to the existing Corporate Social Responsibility initiatives of the Department of Work and Social Economy.
4. ***Improved regulations for SMM*** is mentioned, with principles such as extended producer responsibility, 'end of waste' and life cycle thinking.
5. ***Construction*,** the Programme supports the search for a profitable system to collect windowpanes (flat glass) that are being replaced to meet energy efficiency targets, in order to produce new glass. Moreover, a materials checklist for government buildings is to be introduced.
6. ***Sustainable chemistry and plastics***, and includes the collection of information about the dismantling of waste products in the chemical industry, as a basis for smarter product legislation. Another priority is to develop generally accepted indicators to track the progress in closing plastics cycles and compare these to the best European examples.
7. ***Bio-economy***, the Programme aims to consult government and sectors on the bio-economy, valorise nutrients, list biomass streams and possible applications, identify

[159] http://www.plan-c.eu/wp-content/uploads/2013/01/1.1__plan_c_beeld_anno_20071.pdf

[160] For example iMade (http://imade.be/), a two year project that supports the setting up of infrastructure for business models that combine tailor-made technologies with local service centres that manage resources in a sustainable manner.

and stimulate demand for bio-based products, and consider the bio-economy in renewable energy policy.

8. ***(Critical) metals collection*** is to be increased, illegal networks for metal-containing waste to be restricted, traceability and uniformity of recovered metals to be increased, and there is to be more R&D for closing metal cycles.
9. ***New materials and material technologies for closing cycles*** are to be investigated, integrating bio-based materials in industrial products, and new technologies to recycle complex composites and to recover materials from existing stocks such as industrial landfills. The Programme also aims to develop a tool to assess the impact of nanoparticles on humans and the environment (Vlaamse Regering, 2012a).

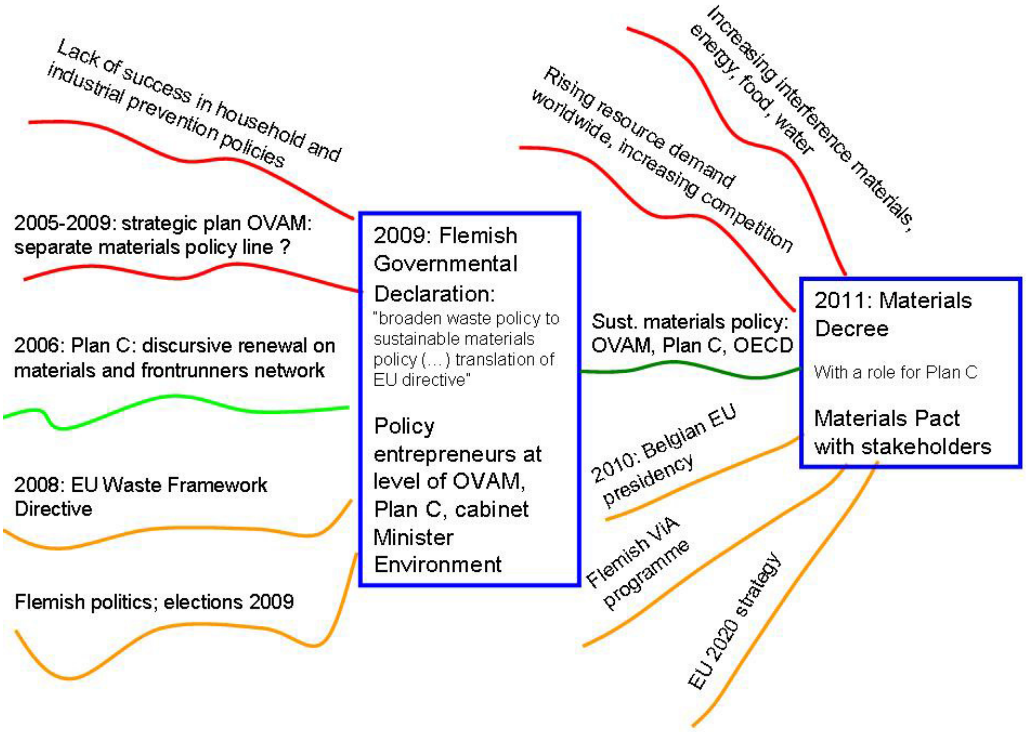
3.3 Drivers / enabling factors

Several factors have driven or enabled the development of the Flemish Materials Programme. An overview of the different drivers, as identified by Paredis and Block (2013) is given in Figure 1 below. Belgium's presidency of the EU Council in 2010 had an important focus on resource efficiency and in particular SMM with conclusions on the topic adopted at the December 2010 Environment Council. These conclusions later played an important role in the publication of the 2011 Roadmap to a Resource-Efficient Europe, which included the objective of national strategies on resource efficiency, including actions on circular economy. Flemish Minister for the Environment Joke Schauvliege was influential in this respect as she, during the Presidency, placed SMM on top of her mandate's focal points. Moreover, during the presidency, OVAM organised a high-profile OECD workshop on SMM (Paredis and Block, 2013).

Flanders' pro-active stance on circular economy can also be explained by the Flemish Government's ambition to be among the top five European regions by 2020 when it comes to SMM (Vlaamse Regering, 2012a: pp 4). Additionally, dependence on imports, geopolitical relations, price fluctuations of raw materials, as well as the strain on the environment have been mentioned as influencing factors, especially after sectoral federations Agoria (technology industry) and Essenscia (chemical industry) demanded government action on these issues (Paredis and Block, 2013). The development of the Programme may also have been encouraged by the issue of end-of-life vehicles, of which around 500,000 are exported annually from the port of Antwerp for second or third life in developing countries, which can lead to environmental impacts and loss of critical metals due to substandard recycling techniques.

Besides the Flanders in Action plan, other policies that may have supported the development of the Programme include the 2009 Strategic Policy Plan 2010 - 2015 on Waste, Materials and Soil Management, and the annual Flemish Reform Programmes which include SMM as a priority (Vlaamse Regering, 2012a). Moreover, the Flemish Environmental Policy Plan for 2011-2015 includes actions to stimulate environmentally friendly production and consumption, including objectives on eco-efficiency, the consumption of materials, natural resources and energy, and renewable energy (EEA, 2011).

Figure 1: Drivers of the Flanders' Materials Programme



Source: Paredis and Block (2013)

The Flemish Public Waste, Materials & Soil Agency (OVAM) has been an important driver of policy in this area. The shift from waste to materials management, and the specific proposal to translate the Waste Framework Directive into a Materials Decree instead of into a new Waste Decree has even been identified as a manoeuvre to keep waste prevention policies under responsibility of OVAM rather than the general environmental department LNE (Paredis and Block, 2013). After the concept of broadening waste policy to sustainable materials policy had been successfully inserted into the Governmental Declaration (Vlaamse Regering, 2009, pp 58-59), the coinciding EU-level action and the Flemish elections opened a policy window for SMM (Paredis and Block, 2013). The work of the Ellen MacArthur Foundation may also have influenced the development of the Programme, as it helped create an understanding between societal actors that they are all tackling the same challenge (De Schoenmakere, 2014).

3.4 Barriers and how these were overcome

Although specific barriers were not identified, the Materials Programme text does mention that the global context, the complexity of the resource challenge and the interconnectedness of the economic, ecological and social dimensions require a focus in Flanders on those material streams for which Flanders can make a difference on a European and a global scale

(Vlaamse Regering, 2012a). Moreover, the Materials Programme is set up following the concept of transition management. However, there has been some criticism on this method. Also, Plan C has suffered from limited funding and a lack of entrepreneurship for realising experiments (Paredis and Block, 2013).

3.5 Main impacts (environmental, economic, social)

As the Materials Programme was launched only two years ago it is difficult to identify specific environmental, social and economic impacts[161]. However, an important achievement was the agreement on an action plan, the mobilisation of partners for all 45 actions in the plan, and the setting up of a research centre for SMM. The **added value** of the programme is also said to be that it accelerates action, renews discourse, builds partnerships, streamlines different initiatives, creates public support, and guarantees continuity in the approach. Although at the time of the launch of the programme several sectors were already taking action to increase SMM, many initiatives were fragmented or overlapping. The programme has increased cooperation, created a new discourse in Flanders about SMM and started a network of frontrunners (Paredis and Block, 2013), e.g. in the FISCH[162], CORE[163] and i-Cleantech Vlaanderen[164] projects. However, it has been said that the Programme needs to be scaled up (Bachus, 2013).

The **first results in the fields of biomass, critical metals, building and sustainable chemistry and plastics** were presented by Minister Schauvliege at the 'Urban mining' congress on 12 November 2013[165]. These include:

- A revision of regulations to facilitate ***collection of small electronics.***
- Launch of a '***consu-sharing***' project[166] which promotes 'shared consuming', where people lend, share or rent products such as cars, clothing or housing.
- An OVAM ***Sustainable Innovation System Toolkit*** has been developed, which familiarizes future employees in various sectors with the principles of SMM.
- A ***materials methodology*** has been elaborated to measure the environmental impact of building elements.
- The ***SYMBIOSE platform***[167] is a matchmaking service platform for valorisation of waste and by-product streams, which promotes collaboration between producers aimed at reallocating one company's residues as another company's raw materials.
- The Flemish chemicals and plastics industry has initiated ***pilot projects for more selective collection, for high-value recycling of plastics and for a quality label for recycled plastics***, which is hoped to eliminate the bias against recycled plastics.

[161] SuMMa is currently preparing a mid-term SWOT-analysis of the programme and expects to publish a report in mid-2014 (Steunpunt Summa, 2013). However, this report will focus on the organisational and process factors that can influence the effectiveness of the program, rather than provide an overview of the Programme's impacts (Personal communication, 2014).

[162] The Flanders Innovation Hub for Sustainable Chemistry (http://www.fi-sch.be) aims to identify, stimulate and catalyse innovations for sustainable chemistry in Flanders.

[163] The CORE project looks at COntrolled REcycling and aims to match the competences of waste management companies to those of the plastics and textiles companies to turn waste into a valuable resource.

[164] I-Cleantech (http://www.i-cleantechvlaanderen.be/en) is a network organisation that aims to identify and stimulate development of cleantech instruments.

[165] http://www.vlaamsmaterialenprogramma.be/congres-12-november

[166] http://www.vlaandereninactie.be/projecten/consudelen

[167] http://www.fi-sch.be/nl/symbiose/

- Moreover, Flemish design academies have signed an ***agreement in which they commit to incorporating sustainable design in their curricula***, and there is an Ecodesign in Higher Education toolkit.

Pilot projects on **flexible construction** are also being initiated in social housing, to allow buildings to be adapted to changing societal needs. Moreover, OVAM is working to develop instruments to measure the **environmental impact of building components**. Furthermore, the interdepartmental working group bio-economy has drafted a vision and strategy for a **sustainable bio-economy**[168]. Demonstration projects on **phosphorus recovery** from waste water, sewage sludge, and manure are in the making, and the available biomass and possible applications are being systematically listed.

Moreover, WEEELABEX (WEEE LABel of Excellence) standards for collection and recycling of **'e-waste'** have been submitted to CENELEC (European Committee for Electrotechnical Standardization) which is now translating the standards into official EN standards. Moreover, the department of environment has signed an agreement with industry federation Agoria to halt the illegal export of waste through Flemish ports. For the collection of **discarded vehicles**, progress has been made on the legal framework for the cooperation between the federal and local governments. This allows the traceability of vehicles to be realised more quickly and the government can promote the collection more rapidly (Vlaamse Regering, 2012a). Also, **Roadmaps** for turning Flanders into a circular economy have been developed, including sub-roadmaps for bio-economy, building sector, (critical) metals and plastics (Expert input, June 2014).

Experts also maintain that because of the Programme, fewer products and materials are incinerated as products are increasingly used for a longer period of time, reused, and used for other applications. Moreover, due to increased control over a product's lifecycle, environmental impacts abroad are also reduced; as recycling often involves less energy than extraction of virgin materials, there are also positive energy and climate change impacts (Expert input, June 2014).

The Programme has also had some **economic impacts**. For example, increasing material costs have risen up the economic policy agenda and have created awareness among sectoral actors. The Programme has led to the setting up of a cluster and smart specialisation policy as promoted by the European Commission. Moreover, better dialogue between stakeholders has given entrepreneurs information on possibilities for co-operation along the value chain (Expert input, June 2014).

The **social impacts** of the Programme mainly relate to meetings between employers' organisations and trade unions to explore potential synergies with skills development. A start has been made to introduce the theme of SMM in school curricula, to increase

168 http://ebl.vlaanderen.be/publications/documents/55073

understanding of the SMM challenge and instigate a change in consumer behaviour. The multi-actor approach has improved dialogue between different stakeholders, and thus created more understanding, collaboration and a joint action plan, despite sometimes conflicting stakeholder agendas (Expert Input, June 2014).

The Programme did not encounter any real opposition, which may be explained by the fact that it was brought forward as part of the Flanders in Action plan (for which there was a mandate) and the fact that the Flanders in Action plan is based on a Pact (Pact 2020) between many stakeholders and thus enjoys sufficient public support. Most stakeholders welcomed the fact that the Programme aims to streamline the fragmented SMM actions. However, despite the absence of real opposition, there are **tensions with other Grand Societal Challenges** such as sustainable energy use, smart mobility, and sustainable building and living. Thus, programme managers aim to deliberate with other transition managers and with political leaders (Expert Input, June 2014).

3.6 Any particular sensitivity to the specific needs of SMEs

OVAM's Sustainable Innovation System toolkit helps SMEs make their business operations more sustainable. Moreover, OVAM, supported by Enterprise Flanders, commissioned the development of a materials scan, where advisors study an SME's material use and identify opportunities for more efficient resource use, use of recycled materials, and re-use or selling of by-products. In 2013 and 2014, this instrument has helped some 250 SMEs reduce their environmental footprint and their production costs, free of charge.

3.7 Potential for replicability / transferability and main lessons

Similar initiatives are currently being discussed in Catalonia and Denmark. However, the success of implementing a similar Programme elsewhere would depend on the knowledge available, experience, waste management results, actors, and previous collaboration between different stakeholders (Expert Input, June 2014).

Experts consulted in the course of the study noted that EU action in this area should not keep innovating frontrunners from advancing, but rather set clear goals, provide country-specific recommendations, ensure lessons from identified best practices are taken forward, support transition thinking, and engage all stakeholders in a chain (Expert Input, June 2014). **Engaging all stakeholders is challenging** and time-consuming (to identify the right people, gain their trust, and move from bilateral contacts to multi-actor collaboration). In Flanders, a number of projects under the Programme involve setting up a **'circle of confidence'** which specifies conditions to enter/exit which are needed to allow stakeholders to share information effectively and come to new ideas, research, entrepreneurship etc. To involve sectoral federations it has been important to look for products where Flanders has designers, production capacity, and processors to sufficiently control the chain. These constructions can however be rather fragile and context/country-dependent. Also, the return on investment is often not immediately visible, thus engagement requires a certain amount of trust (Expert Input, June 2014).

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4. Ferrara LOWaste GPP Initiative

4.1 Brief summary of the case

The LOWaste (Local Waste Market for Second Life products) programme was launched in the municipality of Ferrara (estimated population of 135,000), in the Emilia-Romagna Region of Northern Italy in September 2011. The programme focusses on the development of **lifecycle thinking**, **eco-design** and local **recycling markets**. It also establishes specific **GPP criteria** which are to be integrated in purchases by the municipality.

The programme aims to increase recycling of municipal waste by 70 per cent, decrease CO_2 emissions (in the form of material diverted from landfills) and increase recovery of raw materials (EC 2008a). The programme targets four waste streams: hospital textiles, end-of-life street furniture (e.g. playground equipment) food waste, demolition and construction waste.

The project has already produced important results over the past three years in terms of saved carbon dioxide emissions, reused materials and the integration of green public procurement practices within the municipality. It is considered an interesting case of an initiative driven by the municipal level and engages local actors.

4.2 Description of case and how it supports a circular economy

The **main objectives** of the LOWaste initiative are to reduce locally produced waste, raise awareness regarding waste prevention and reuse, create new jobs opportunities and support GPP. The LOWaste programme was structured into four main phases. The first phase (January-September 2012) comprised of a comprehensive a lifecycle analysis of various types of waste which led to the selection of four waste streams to focus on, namely: **hospitals textiles, demolition and construction waste, street furniture and food waste.** In the second phase of the initiative (September 2012-November 2013), the project assessed the different legal frameworks in relation to each selected waste stream and explored how to optimize waste management operations in each area. During the third phase (November 2013 - February 2014), actions were taken to create a partnership and a 'code of conduct' to integrate products derived from waste into the local market through the use of **GPP practices**. The fourth phase aims to further '**mainstream'** the products into the local market by June 2014. This objective is to be reached by awareness raising campaigns, through the creation of a proactive community of people and annual workshops (LOWaste Expo) to discuss the eco-design of new products (LOWaste 2012, p.3)

The project started in **September 2011** and is expected to run until **June 2014**. Within the framework of the programme, a feasibility study was carried out on the establishment of a

local reuse centre to be used as market platform for the exchange of products which could be reused by other consumers or users.

4.3 Drivers / enabling factors

The adoption of various laws at the regional and national level has facilitated these developments in Ferrara. For example, in 2002 **regional law** LR 29/02 was approved by the Emilia-Romagna region which stated that at least 70% of foods in schools, nurseries and crèches should be organic and biologic. **National legislation** (Law 448/2001 and Law Decree 195/2005) set a requirement for public administration that at least 30% of purchased manufactured goods should be made using recycled materials and to cover up to 40% of total plastics good requirements. Moreover, the legislation also requires the public administration to use energy efficient light bulbs and purchase re-treated tyres for at least 20% of their volume (LOWaste 2013, p.9). After the introduction of the Law 147/2013, GPP became a mandatory requirement for public administration across Italy (Legge 147/2013, 2013).

In 1994 (before the introduction of the LOWaste initiative) the municipality of Ferrara approved a pilot project in which it introduced the use of organic food in school canteens and nurseries (Aalborgplus10.dk, 2004). Following approval of the *Politica Ambientale del Comune di Ferrara* (PG n. 21115/2012), the municipality also started focusing on the promotion of GPP. This policy-framework provided fertile ground for the development of the LOWaste initiative in Ferrara. The LOWaste has also benefitted from **EU funding under the LIFE+** programme of €550,000 (EC 2011, p.3)

4.4 Barriers and how these were overcome

The project has encountered some legislative barriers due to what is at times a lack of clarity in Italian legislation on waste. In particular, there are issues related to the **definition of** "**special waste**" as Italian legislation encompasses a number of different types of waste, from pharmaceutical products to industrial waste. This sometimes reduces certainty for waste management companies. For example residual waste derived from pruning in the city, is considered as "waste", while in the countryside it is considered "biomass", with a different legal status. Furthermore, sometimes, at local and regional level there is a lack of **coherent planning** among different municipalities for recycling hazardous and hospital waste (LOWaste Expo (2014)

4.5 Main impacts (environmental, economic, social)

In Ferrara in 2004, 90 per cent of all meals served in kindergartens, compulsory schools and nurseries were organic (amounting to a total expenditure of €1,440,000 per year)

(European Commission, 2008b). All papers used by the municipality are whitened without the use of chlorine and 40-50 per cent of this paper is 100 per cent recycled (Aalborgplus10.dk, 2004).

The LOWaste initiative between 2011 and 2013 has led to:

- Annual diversion of 90 tonnes of **hospital textiles** away from landfill to reuse and 2,159 tonnes of CO_2 equivalent saved as a result of this diversion.
- At least 11,200 tonnes of recycled **construction** and **demolition waste** materials used for the construction of **roads** and **cycling lanes**, resulting in up to 593 tonnes of avoided CO_2 emissions from reuse of materials.
- The refurbishment of **old street furniture** has helped save 90 tonnes of **virgin raw materials** and realized savings equivalent to 67 tonnes of CO_2.
- **Food waste** (including oil waste) has been used for the production of compost, biodiesel and glycerine which has led to an annual saving of 30 tonnes of food waste and the production of 4,500 kg of compost material (LOWaste 2014).

The LOWaste program has also helped create **local jobs** within the market of recycling and reuse. Although the precise number of jobs created is not specified, it has been noted that companies which took part in the projects have had the possibility to provide job opportunities in the recycling industry, including for people from **disadvantaged backgrounds** (LOWaste Expo 2014)

4.5 Potential for replicability / transferability and main lessons

This case illustrates how circular economy activity can be driven through initiatives at the local level and the role of municipalities through the adoption of GPP practices and specific programmes. The adoption of legislation at both the regional and national levels has also been supportive of these efforts at the local level. However, the case highlights some opportunities for revising legislation, particularly at the national level to better support local action, e.g. clarifying 'end of waste' criteria, promoting reuse centres, legislative clarification on the legal definition of "special waste" and product labelling (especially of food products). The current legislative framework in place in Italy is considered to not be optimal for the development of food donation and charity activities with current uncertainty (A21Italy, 2013). Moreover, incineration plants are competing with recycling facilities for getting waste from the municipalities while some waste-to-energy plants built after 1996, are subsidized through a feed-in-tariff mechanism (Autorita Energia Elettrica e Gas 2011)

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5. Waste & Resources Action Programme (WRAP), United Kingdom – *Working draft*

5.1 Brief summary of the case

WRAP works in England, Scotland, Wales and Northern Ireland to help businesses, local authorities, communities and individuals reap the benefits of reducing waste, developing sustainable products and using resources in an efficient way. WRAP has launched a number of successful campaigns and also runs a number of voluntary agreements with different business sectors.

WRAP (2012) estimates that between 2008 and 2011, its activities had the following annual impacts:

- 12.6 million tonnes per annum of waste diverted from landfill
- 6.6 million tonnes per annum of CO_2e less emissions
- 5.7 million m^3 per annum of water conserved
- £2.2 billion per annum of economic benefits (£1.9 billion of cost savings and £376 million of sales growth)
- Over the next decade, activities from WRAP's work to date is expected to generate £3 billion in additional sales for the UK recycling and reprocessing sector and help businesses, consumers and the public sector save £18 billion.

Germany and the Netherlands have been in discussion with WRAP about creating similar organisations in their countries.

5.2 Description of the case and how it supports a circular economy

Established as a not-for-profit company in 2000, WRAP is backed by government funding from Defra (Department for Environment, Food and Rural Affairs), Scottish Government, the Welsh Government, the Northern Ireland Executive, and the European Union. WRAP is a private company limited by guarantee, registered in England.

WRAP was setup to support recycling and create a market for recycled materials. Today, WRAP emphasises the circular economy. In doing so, WRAP works with a wide range of partners, from major UK businesses, trade bodies and local authorities through to individuals looking for practical advice. Developing such partnerships is central to how WRAP works. Such partnerships has resulted in the following achievements:

- More than 45 leading retailers and brands have signed up to the Courtauld Commitment voluntary agreement aimed at increasing resource efficiency and reducing waste in the UK grocery sector. This has helped end the growth in packaging through smarter design.
- Over 800 companies committed to the voluntary agreement to Halve Waste to Landfill in the construction sector by 2012.
- WRAP's research and funding helped create the first food-grade and mixed plastics recycling facilities in the UK.

- More than a million people each year view WRAP's websites recyclenow.com and Lovefoodhatewaste.com.

The groups WRAP works with include the construction sector, retailers, local authorities, the waste management sector, the agriculture sector, the hospitality and food services sector, SMEs and individual consumers. WRAP provides companies and local authorities with information and guidance about good practice and how to operate schemes to minimise and recycle waste. WRAP also manages voluntary agreements with business sectors:

- The Courtauld Commitment with the grocery sector.
- The Home Improvement Sector Commitment.
- The Voluntary Carrier Bag Agreement with seven major supermarket chains.
- The Federation House Commitment, a voluntary agreement which aims to help reduce overall water usage across UK Food and Drink industry by 20% by 2020.
- The SCAP 2020 Commitment with leading organisations from across clothing sector – supply, re-use and recycling – working together to reduce the environmental footprint of clothing.
- The Business Recycling and Waste Services Commitment.

Also, WRAP has funded the development of a world-first technology for the closed-loop recycling of plastic bottles, which led to the creation of a new market for recycled plastics in the UK.

5.3 Drivers/enabling factors

The key driver behind WRAP's activities has been government policies to reduce waste and to increase recycling:

- Producer responsibility for packaging waste was introduced under the Producer Responsibility Obligations (Packaging Waste) Regulations in 1997, following the 1994 Packaging and Packaging Waste Directive (94/62/EC). The regulations have subsequently been amended a number of times and the targets for packaging recycling have increased (BIS 2014).
- The Landfill Tax was introduced in 1996. Landfilled waste is charged at a lower rate if it is inactive, which covers most forms of construction waste. Active waste is charged at a higher rate. The landfill tax rates were low, but the rate for active waste has risen very substantially from £7 per tonne in 1996 to £80 per tonne in 2014. Landfill tax is paid by operators, but it is passed on to companies for industrial waste and it is passed on to local authorities for household waste (HM Revenue & Customs 2014).

The majority of local authorities had low recycling rates at the time that WRAP was formed. The Waste Strategy 2000 set national targets for England (with similar targets were set for Scotland, Wales and Northern Ireland):

- To reduce the amount of industrial and commercial waste sent to landfill to 85% of the 1998 level by 2005.
- To recover value from 40% of municipal waste by 2005 (45% by 2010 and 67% by 2015) (Recovery includes recycling, composting and energy recovery).
- To recycle or compost at least 25% of household waste by 2005 (30% by 2010 and 33% by 2015).

Progress was slow until the introduction of statutory recycling targets for local authorities in 2003. Defra (2007) reported that:

- Recycling and composting of waste had nearly quadrupled since 1996-97, achieving 27% in 2005-06;
- The recycling of packaging waste had increased from 27% to 56% since 1998;
- Less waste was being landfilled, with a 9% fall between 2000–01 and 2004–05; and
- Waste growth was being reduced with local authority domestic and business waste collections growing much less quickly than the economy at 0.5% per year.

The Waste Strategy 2007 (Defra 2007) put greater emphasis on waste prevention and set new, more ambitious targets:

- A target to reduce the amount of household waste not re-used, recycled or composted from the 22.3 million tonnes in 2000 to 12.2 million tonnes in 2020 (with a target of 15.9 million tonnes by 2010) - a reduction of 45%.
- Higher targets for recycling and composting of household waste – at least 40% by 2010, 45% by 2015 and 50% by 2020. These are significantly higher than the Waste Strategy 2000 targets of 30% by 2010 and 33% by 2015.

These policies have created incentives and targets for businesses and local authorities to reduce waste and increase recycling.

5.4. Barriers

WRAP's work focuses on overcoming barriers to waste reduction and recycling. WRAP does this by providing information and guidance about good practice in reducing waste and recycling. WRAP also seeks to overcome barriers within sectors by facilitating voluntary agreements with various business sectors. WRAP's role is to inform and encourage and to help coordinate sectoral action, rather than to force action in the way that regulations or economic instruments can.

5.5 Main impacts (environmental, economic, social)

WRAP (2012) estimates that between 2008 and 2011, its activities had the following annual impacts:

- 12.6 million tonnes per annum of waste diverted from landfill
- 6.6 million tonnes per annum of CO_2e less emissions
- 5.7 million m^3 per annum of water conserved
- £2.2 billion per annum of economic benefits (£1.9 billion of cost savings and £376 million of sales growth)
- Over the next decade, activities from WRAP's work to date is expected to generate £3 billion in additional sales for the UK recycling and reprocessing sector and help businesses, consumers and the public sector save £18 billion.

5.6 Particular sensitivity to the specific needs of SMEs

WRAP engages with SMEs. WRAP provides advice and guidance about reducing waste and recycling specifically aimed at SMEs. There is a particular emphasis on food waste recycling by SMEs in hospitality and food services. WRAP conducts feasibility and demonstration trials to find good practices for recycling services for SMEs. Most of WRAP's funding for other organisations is aimed at SMEs and re-use organisations in the third sector.

5.7 Potential for replicability / transferability and main lessons

What WRAP could potentially be replicated in other countries, even though many European countries are further advanced than the UK in recycling and waste minimisation. There would be particular benefit for countries that have not progressed so far as the UK in recycling and waste minimisation to replicate WRAP. However, there may still be potential for countries that are more advanced than the UK to replicate WRAP's approach of an organisation providing information about best practice to local authorities, business and consumers, trying to catalyse the activities of others by bringing them together and funding the development of new recycling technologies. Germany and the Netherlands have been in discussion with WRAP about creating similar organisations in their countries.

Perhaps the greatest element of WRAP's successes lays not just in what they do, but how they form partnerships to achieve their goals. Behind this is the institutional setup behind WRAP as not-for-profit-company with the freedom to recruit and achieve its remit in each particular sectoral cultural context that it faces. If other MSs are to create similar organisations in their countries, this approach would need to be translated into the new cultural setting, rather than necessarily replicated.

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Unless otherwise stated, all information is from the WRAP website www.wrap.org.uk.

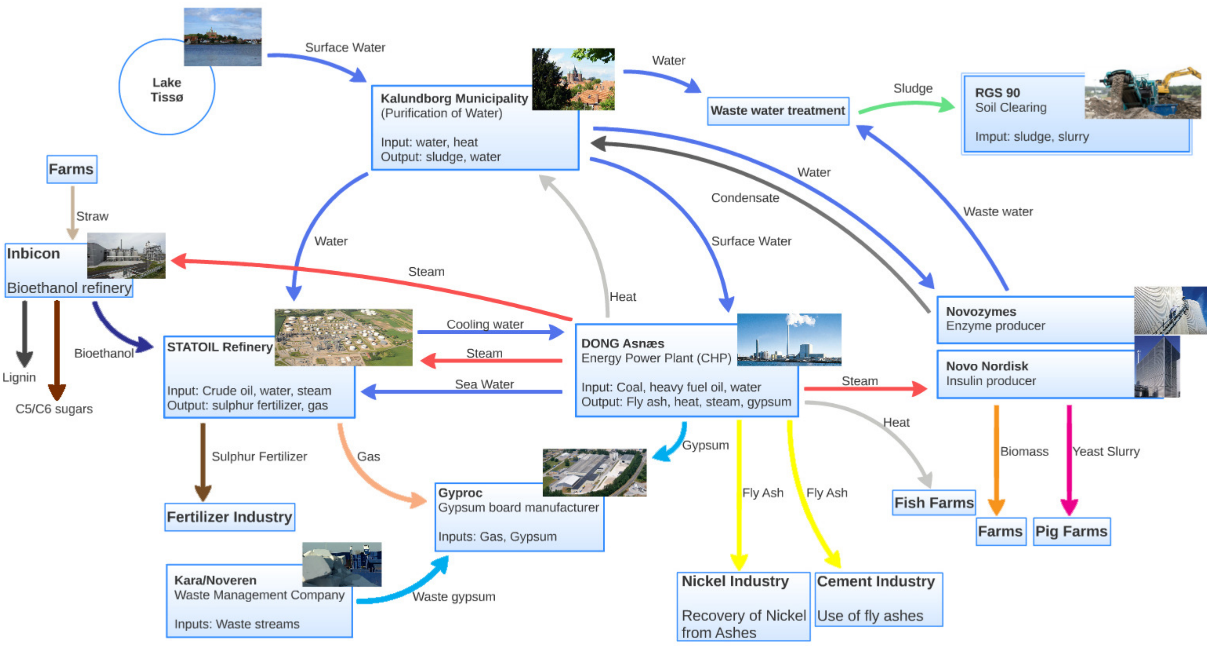
6. Industrial Symbiosis in Kalundborg, Denmark

6.1 Brief summary of the case

Kalundborg is considered as one of the first and most successful cases of industrial symbiosis[169] implemented to date. Since the implementation of the first connections in the 1960s, the **number of companies involved** as well as the **network of exchanges** between the companies has **increased**. This has led to substantial reductions in the consumption of virgin materials, reduced GHG emissions, reuse of waste-energy flows, reduced environmental impact of companies and ultimately to the exchange and re-use of several types of waste streams (Domenech & Davies 2011a, p.81). The project has also led to **important material and energy savings** for the economic actors (municipality and companies) involved.

6.2 Description of case and how it supports a circular economy

Figure 1: Graphical representation of the Kalundborg industrial symbiosis project



Source: Author's own elaboration based on Domenech & Davies (2011a), Jacobsen (2006), Kalundborg Symbiosis (2014a)

169 Industrial Symbiosis usually involves connecting what are previously disconnected industries or entities through a "collective approach" which aims to achieve a competitive advantage through physical exchanges of water, energy and by-products. These exchanges are also made possible through the geographical proximity of different companies (Chertow & Lombardi 2005).

The first linkages were made between the local power plant and the oil refinery in the 1970s. Gas was piped from the refinery to the Gyproc plant and Novo Nordisk started shipping sludge (biomass) to farmers (Jacobsen & Anderberg 2004, p. 319) During the 1980s, heat and steam connections were added between the power plant the municipality of Kalundborg, the fish farm, the oil refiner and Novo Nordisk. The connections increased in complexity over the years and now the Kalundborg industrial symbiosis project involves nine public and private companies[170] which form an essential part of the functioning of the network. Figure 1 above provides a simplified illustration of the industrial symbiosis project. As can be seen, cooling water and wastewater from the STATOIL oil refinery are used by the DONG Asnæs CHP power plant in their cooling procedures. The power station produces steam, electricity, heat and industrial gypsum. The industrial gypsum is in turn sold to Gyproc (a local plastic board manufacturer), thus replacing the use of imported natural gypsum. The steam is used by the Novozymes (enzyme producer) and Novo Nordisk (an insulin producer), the Inbicon bioethanol factory and the STATOIL refinery. Fly ashes from coal combustion of the power plant are used in the local cement and nickel industry. The CHP system of the DONG Asnæs power plant also provide district heating in the Kalundborg municipality, heated cooling water is used to increase the yields of local fish farms. Novo Nordisk provides biomass to local farmers and surplus yeast for pig feeding (OECD 2009, p.36). The STATOIL refinery produces liquid fertilizer from its desulphurisation facility which is used in the fertiliser industry and butane gas which is used by Gyproc. Waste gypsum from the Kara/Noveren waste management company is also used by Gyproc. Inbicon supplies STATOIL with second-generation bioethanol made from local straw (Inbicon 2009). The municipality of Kalundborg supplies water and as the local wastewater company sells its residual sludge to a soil recycling company (RGS 90).

6.3 Drivers / enabling factors

The implementation of the Kalundborg industrial symbiosis project was driven by a number of factors. Concerns related to **water consumption** where low groundwater availability in the municipality and the development water-intensive processes at the power plant, increased the need for a more diverse water supply strategy (Jacobsen 2006, p. 253). There was an economic assumption that increased synergy between the different companies would lead to **substantial economic savings**. Implementation of the industrial symbiosis was also considered to reduce the **environmental impact** of industrial activities in the area. Furthermore, enforcement of **environmental regulation** (such as sulphur standards, which triggered the construction of the desulphurization plant at the Asnæs power station) provided a further stimulus for the development of linkages between the different industries.

[170] The companies involved in the Symbiosis are : The Statoil oil refinery (*Statoil raffinaderiet*), the DONG power plant (Ansaesvaerket A/S), the Gyproc gypsum board manufacturer (Gyproc A/S), fish farms specialized in trout culture (Asnaes fiskeindustri A/S), An Enzymes producer (Novozymes), an Insulin manufacturer (Novo Nordisk) a bioethanol factory (Inbicon), a soil remediation company (RGS 90), the publically-owned waste water company wastewater company (Kalundborg Forsyning A/S), a local cement and nickel company and a waste management company (Kara/Noveren).

The development of **environmental legislation** has also been a driving factor. The first linkages between the enterprises were in the 1970s and aimed to achieve GHG **emission reductions** (Jacobsen & Anderberg 2004, p. 322). The second wave of expansion in the early 1980s aimed to achieve substantial **energy savings** and was also in response to the **second global oil shock** in the late 1970s. Initiatives in the late 1980s focused on improving waste water management which were seen as **political priorities** at the time (Jacobsen & Anderberg 2004, pp. 322-323). The development of the project was supported by open and continuous negotiation between public authorities and companies rather than through emission standards or fixed technological standards (Jacobsen & Anderberg 2004, pp. 322-323)

6.4 Barriers and how these were overcome

A number of factors can act as barriers to industrial symbiosis, for example **low energy prices** (especially crude oil) could reduce incentives for the implementation of industrial symbiosis projects. **Location** is also an important factor to be considered, as opportunities for symbiotic activities increase with the geographical proximity of different industries (Jacobsen & Anderberg 2004 p. 320). Both factors were favourable in the case of Kalundborg. The Kalundborg case is also based on the fact that the industries have **stable waste streams** and a **continuous need** for **inputs**, which may not always be the case. In addition, the initial amount of **investment** which was **needed** to develop the **infrastructural** connections and **utility sharing** (e.g. steam pipes) between the different industries was provided through the companies.

6.5 Main impacts (environmental, economic, social)

It has been estimated that waste exchanges between the companies are equivalent to 2.9 million tons of materials each year (OECD 2009, P.36) and have led to the reduced extraction of raw materials. For example, more than 75% of the plasterboard manufactured at the Gyproc plant is based on **industrial gypsum** from the desulphurization unit of the DONG power plant (Jacobsen & Anderberg 2004, pp. 322-323). Industrial symbiosis has also helped industries to reduce **extraction of fresh groundwater** (Jacobsen, 2006 p.243-246) through a diversification of water sources (surface water, cooling water and wastewater). For example, between 1990 and 2002, it has been estimated that some **30 million m_3** of groundwater was saved by the industries. By 2013, 3 million m^3 of water was saved annually (Kalundborg Symbiosis, 2014b) and the DONG power plant had decreased water use by 60% (Gibbs 2008, p.1144). Furthermore, industrial symbiosis has also led to an annual saving of more than **64,000 tonnes of CO_2** (Domenech & Davies 2011a, p. 81)

In 2014, the Kalundborg municipality manages heat and water supplies for **50,000 inhabitants**. (Kalundborg Symbiosis 2014b). Interaction between the industries are fostered through bilateral agreements which has increased **trust** and stimulated **mutual communication** among the different partners and managers (Almasi *et. al*. 2011, p.28) **Co-operation** between the different **companies** involved has been essential for the realisation of the successful case of industrial symbiosis.

6.6 Potential for replicability / transferability and main lessons for others

The example provided by the Kalundborg symbiosis has inspired initiatives in other areas of the world, with different environmental and economic backgrounds (e.g. Barceloneta/Guayama (Puerto Rico), Kwinana (Australia) and Rotterdam (the Netherlands) (Chertow 2007, p.22). Therefore, there may be opportunities to implement similar initiatives in other areas.

Contractual obligations[171] between the power plant, the municipality of Kalundborg and companies incentivized the development of new linkages and exploration of further energy and material exchanges (this also provided the basis for increasing the use of surface water and for more cooling and wastewater exchanges) (Jacobsen 2006, p. 253). A similar approach could thus be considered in initiatives in other areas.

There are also interesting cases of industrial symbiosis at the national level. For example, the **National Industrial Symbiosis Programme (NISP) in the UK** is claimed to be the only national programme on industrial symbiosis in the world. Launched in April 2005, (Paquin and Howard-Grenville 2012, p. 85) the NISP inspires companies to implement resource optimisation and efficiency practices, keeping materials and other resources in productive use for longer. (Lombardi & Laybourn, 2012 p. 30) The NISP provides a platform to share best practices, it also provides advice and a networking programme for companies' interested in taking advantage of potential synergies from industrial symbiosis. (Domenech & Davies 2011b, p. 290)

The main objectives/aims of the programme are to build connections between different companies, analyse any potential synergies or exchanges that could lead up substantial economic and environmental benefits and promote pilot projects with potential for recycling or reuse of waste streams (Domenech & Davies 2011b, p. 285). The NISP has contribute to a reduction of 8 million tonnes of CO2, 45 million tonnes of landfill diverted, 12 million tonnes of virgin material saved and 14 million tonnes of water savings annually. The NISP also helped create more than 10,000 jobs and cost-savings equivalent to €243

[171] One example of such a contractual obligation is the wastewater exchange between the refinery and the power plant. The wastewater is not priced and the contract does not have any time limitation. The provision of waste water from the refinery to the power plant helps the refinery meet discharge limits while reducing freshwater water consumption by the power plant (Jacobsen 2006, p. 247).

million per year. Over a five-year period, the programme delivered roughly €1.5 billion worth cost savings (Laybourn 2014, p. 17).

The NISP was financed by the UK government from April 2005-April 2014, the programme is currently looking for funding from other sources, especially for the development of IS programmes in regions which could benefit from financing by the European Regional Development Fund (European Commission 2014).

According to analysis by COWI (2011), replicating a similar programme at EU level, is estimated to yield up to €1.4 trillion savings and more than €1.5 trillion additional turnover172, with a public expenditure of just €250 million (COWI 2011, p. 72).

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Annex 5: **Complementary analysis:** Why going it alone can be ineffective, why collaboration can be tricky, and why this gives policy makers another role

1. Introduction

If a firm manufacturing consumer products wants to change to become more circular, it can either:

- Go it alone - do what it can by itself; or
- Collaborate - enlist customers and suppliers that will help it.

The second choice is often the change that policy makers want to see.

1.1 The limits of going it alone

Many of the opportunities to reduce the costs of resource use can only be realised by firms working with others, along their value chain. When a firm (let's call it 'Circex') assembling electronic products wants to change that product design, it is limited by what its components suppliers are prepared to offer it for assembly. Perhaps some of those will fit a redesigned product, but some will have to be different. Circex can look round the market to find components suppliers offering alternative components that better fit a circular design. But the component options are still limited by what's currently sold on the market.

To make progress with design for circularity, particularly radical progress, it is likely that Circex will have to incorporate some innovative components. Circex might not have the capability to design and built those itself. This means that it needs to collaborate with existing or potential suppliers to design and have those components manufactured.

Circex's challenge is common: many of the most successful industries are based on high levels of specialisation of different parts of the supply chain: our famous vehicle manufacturers (like BMW or Toyota) are now truly vehicle assemblers, rather than manufacturers: they put the cars together from components supplied by a web of suppliers. The smart phone value chain (see case study in Annex 6.1) also shows significant specialisation.

The need for collaboration to make progress on the circular economy isn't ubiquitous. But it affects any firm who needs change in their suppliers to change their own practices or products.

It is also an issue with customers: firms wanting to change what they offer to customers, that would improve circularity, may have to convince customers that they would benefit from innovation, and so induce them to make some changes that would allow the new product or service offer to be successful (for example, investment by the customer in new recycling infrastructure, or data gathering).

And it is also often an issue for anyone trying to close the loop - establishing new collection and resale or reuse routes frequently needs cooperation between different actors in that value chain. These can be processors or local authorities (whom often act rather like commercial operations in their waste management, so for simplicity of language we include them in the term 'firm' in this note).

1.2 Contents of this Note

This paper looks at the challenges of firms' cooperation for circularity among value chain partners, and the role that policy makers can take, in making that happen.

This goes to the heart of business practice, so is based on examples and analysis from business research. It is divided into 3 sections:

- Investment and Constraints on Value Chain Collaboration
- Success and the role of Power
- Implications for Policy

2. Investment and Constraints in Value Chain Collaboration

Innovation for circularity involves investment. This can be small, and pay back very quickly. It might only be investment in skills, rather than equipment. But it's still investment. And whether the returns on investment are financial (as they normally are) or more strategic or reputational, firms (including customers) will base decisions to invest on notions of the return they will get on the investment.

On top of any investment internal to a firm, building suitable value chain relationships and making them work is itself an investment of skilled time. That's an additional consideration.

Whether a value chain collaboration will get going will, according to the literature, depend on whether the different potential collaborators perceive that they will get a sufficient return on their investment from that collaboration. There are barriers which can prevent that perception forming:

2.1 Uncertainties in return on investment:

Everything about the future is uncertain. Investment is a risk. Factors which increase uncertainty around return on investment hold back that investment. A key factor in uncertainty is whether the **relationship with a value chain partner will last** long enough for the payback to come.

Our example firm, Circex, might persuade a supplier to invest, then in a year's time change its plans, or swap to another supplier. In most competitive markets, there is little assurance that a commercial partner (like a purchaser) will stay in a commercial relationship, rather than swapping to another partner where there is short term gain. That could make collaborative investments worthless, so doubts about the commitment to a lasting commercial partnership limit the attractiveness (or expected payback) of investments based on value chain co-operation.

This makes **trust** an important factor. There are two drivers of trust: the intellectual analysis that an ongoing relationship really is in each firm's interest, and the more human, affective (i.e. emotional) assessment of the trustworthiness of the people in the other firms which you are dealing with. Business is based on human relationships.

Sufficient trust in the other firms' confidentiality and constraints in use of the sensitive information provided during the collaboration, is also essential.

2.2 Capacity:

Weak innovative capacity in one or more of the relevant actors in the value chain would block innovation. Other capacity constraints in actors would also be blocks lack of top management commitment, **inappropriate internal organisational structure** or **skilled staff** to support value chain collaboration.

There also needs to be someone who has the motivation and **capacity to co-ordinate** the value chain co-operation. They need to have the skills or influence to make others want to, or submit to, be co-ordinated.

More complex, longer, or international value chains increase the challenges and risks of successful collaboration.

2.3 Culture:

An **absence of complementarity in strategic approach** between partners acts as a barrier. So does a dissimilarity of management culture or corporate goals. Co-operation includes the exchange of information - and requires firms who can **'speak the other's language'.**

2.4 My share of the benefits:

Every firm that is collaborating needs to benefit in some form, for them to be motivated. A good value chain collaboration should realise returns: perhaps from increased profit margins, from reduced costs, or new sources of revenue (from recycled material). There is no law deciding which of the value chain collaborators captures these increased returns. In practice, the **share of returns can be decided by the relative market power** of firms in the value chain.

In many value chains, there will be a power imbalance, and some actors in that value chain can exert pressure on other value chain members to capture a greater share of profits from the final sale of the product. Where there are power relationships which imply that some actors in the value chain will not stand to gain significant from any increase in circularity (because someone else is capturing the value), that is likely to prevent co-operation.

3. Success and the Role of Power

The business research dealing with supply chain co-operation has put some effort into categorising the market conditions where the constraints above can be overcome. It often builds on a theory proposed by Fisher (1997).

3.1 Fisher's Categorisation, and the important or relative attractiveness of investment

There is a huge diversity in supply chains, and Fischer attempted to create a simple categorisation that could help identify which types of supply chains are likely to be able to collaborate. He divided supply chains between those which have:

- Stable products and services, predictable market demand, high price competitiveness and very slow change in supply chains (e.g. bread, paper); and

- Products or services with rapid change in their life-cycle, with agile, flexible supply relationships, and innovation in those relationships, with unpredictable demand and higher profit margins

Stability is a feature needed to promote circularity. It increases the chance that investments will have a working life that is long enough to give payback.

The existence of high price competitiveness is also important: it implies that cost savings from resource efficiency/circularity, could make a significant difference in profits, compared to alternative efforts in the supply chain. That would make them an area to invest in.

This **relative attractiveness of alternative investments** is a key factor. It is not enough for an investment to give a positive rate of return, it needs to give a higher rate of return than viable alternatives. When most businesses focus on collaboration in value chains, they do not do it to improve circularity, or resource efficiency. Why? Because they can use their time and money for greater returns from improving the 'business efficiency' of their supply chains - particularly the speed of delivery of products, and the matching of those products to market demand.

That is why Fisher separated stable products from fast-moving products. When products or services are relatively innovative, with market success determined more by 'fashion', supply chain collaborations are likely to get higher returns from better co-ordination of supply with demand: matching production quantities to future demands, for instance. Where there is value chain collaboration on product design, it will aim at the innovations which deliver most profit: in fast-moving sectors (like smart phones), this is rarely circularity.

Fisher's work is a useful conceptualisation. The evidence base behind it is less conclusive - the variety of products and circumstances in value chains makes it hard to generalise, and empirical research in this area is rare.

One of the reasons why value chains do not always follow Fisher in practice, appears to be inefficiency, or poor management capacity. Research by Nagy (2010), based on interviews with businesses in Hungary, found that many firms didn't follow Fisher's predictions of supply-chain collaboration, perhaps just because they were making bad decisions.

3.2 Power and the impact on relationships

There are some impressive examples of value chain collaboration, both for circularity and product innovation. Nike has pulled 144 of its 700+ global suppliers into a 'lean manufacturing' programme. For the 787 Dreamliner, Boeing changed its value chain, so that 70% of the production and development was outsourced to suppliers, working directly with only 50 'Tier 1" suppliers who managed more 500 more suppliers.

Many of these examples come from value chains where one actor has power to influence others. Power is a central issue. Cox, Sanderson and Watson (2001), leading researchers in this field, write: "*Attempts at [co-operation in the supply chain] may only be possible [where] either buyers or sellers are independent or because a buyer is a focal organisation in the chain....and can impose buyer dominance.*"

In brief, value chain collaboration is most common where it is co-ordinated by a powerful actor. Yet it is also blocked where that power is used in a way which means that there is nothing to gain for the collaborator.

3.3 Forms of Power

The word 'power' in relation to supply chain relationships most naturally conveys consideration of the relative dependence of one firm on another: a measure of how damaging (or favourable) it could be for a firm to withdraw (or give) its business to a firm. It can be proxied by measures of the % share of turnover/sales or profit that a firm has with another one, together with considerations of the alternatives in the market. For example, 'channel businesses' - like supermarkets - which have significant power over the distribution of products are in a power position for some of their products (like fruit and vegetables) and can exert influence over their suppliers.

This is only one form of power: as economic actors are human organisations, the wider forms of power include much more human considerations - including normative considerations. French and Raven popularised a categorisation of forms of power (in 1959) which is still widely used. It categorises power into:

- Coercive Power - based on the threat to impose costs, for example by withdrawal of business
- Reward Power - based on an ability to favour a firm, with more profitable contracts, or continuation of business, when it performs well
- Referent Power - coming out of the desire for one firm to be associated with another
- Expert Power - influence from being able to offer expertise (eg. technical expertise) to another firm
- Legitimate Power - coming out of a perception by one party that the other has a right to do something (for example, because it is written into a contract).

Research by business researchers, in the USA, China and elsewhere, indicates that the type of power which exists, or which is used by a powerful actor, has an impact on the success of value-chain co-operation.

3.4 Use of Power

Successful value-chain co-operation needs a belief in ongoing commitment, which is based on trust and belief: both highly related to emotional factors. Relationship commitment is shown in the willingness of a party to invest resources in a relationship (Morgan & Hunt, 1994). Actions which increase trust and feelings of partnership increase the success of co-operation. Reward Power, Expert Power, Referent Power and, to an extent, Legitimate Power have been found (in research based on interviews) to do this. (e.g. Frazier & Summers, 1986) These can increase the normative (or emotional) relationship between firms, which facilitates co-operation.

The use of coercive power does not do this, and there is some evidence that the kind of instrumental relationships which it does promote may not be so stable. This is, in part, because businesses are often naturally short term, and instrumental relationships are therefore also typically perceived as short-term. “As... intrinsic factors become central, extrinsic factors such as rewards and punishments, become less important" (Brown et al., 1995, p.368)." Research in China points to different forms of power being more effective in different cultures: in China, expert power was found to be stronger than in the USA, which the researchers attribute to a strong respect for authority in Chinese culture. (Zhao et al, 2008).

This categorisation of power is useful in explaining the differences between business practices (such as those examples described in the case studies in other Annexes).

Japanese motor manufacturers - particularly Toyota - pioneered value chain management in the late 1970s and 1980s, focusing on managing supply relationships to innovate for efficiency and cost/value improvements in their cars. They were able to do this, for several reasons, one of the most important being that they sat at a dominant position relative to many of their suppliers. However, they also made considerable use of 'expert power', building relationships with their suppliers by sending their experts to work with suppliers to improve their business. This contrasts to practices by US car makers, who had significant power (in the early 1990s, 5 assemblers in the US had 90% of the automobile market). They made much greater use of coercive power in their value chain relationships, for example imposing non-negotiable price reductions on their suppliers. Although this saved short term costs, it did not promote collaboration. (Maloni and Benton (2000)).

Nike has combined its use of power to promote cost-saving 'lean manufacturing' amongst its suppliers. It only provides its expertise when suppliers have complied with a set of monitoring practices. (Porteus and Rammohan (2013)).

There has been very little research into collaboration for product innovation that brings greater circularity. The majority of research looks at collaboration for profit maximisation by other means, with a little on the use of value chain influence to promote the adoption of environmental management systems. Some empirical research in relation to environmental improvements in the value chain has been conducted in relation to requests for suppliers to disclose carbon emissions, under the aegis of the Carbon Disclosure Project. Research into success of requests for carbon information found that success was higher where there was greater trust, and where supply of carbon information was seen as a usual, or increasing business practice. (Jira and Toffel (2012).

4. Implications for Policy

Policy makers armed with clear ideas about the needs and opportunities for value chain collaboration for circularity have a greater chance of success, particularly for radical change. There are 7 reasons why:

1. The potential difficulties in value chain co-ordination have implications for policy design. By understanding the nature of value chain relationships, policy makers can shape policy appropriately **to create all the conditions needed** for successful co-operation, or to avoid wasted effort where this is not possible.
2. Excessive complexity and cultural difference is often involved in efforts to increase circularity. Some of those efforts need collaboration between firms, consumers, waste collectors, including municipalities and processors. This implies that **finding ways to**

simplify the complexity may be needed. One of the easiest is to increase the strength of the market signal (where that is possible).

3. Assessing the value chain can indicate who stands to benefit from a circular economy innovation, and whether there are **sufficient winners for collaboration to take place**. This assessment can also help policy makers build sufficiently strong coalitions to support relevant policy change.
4. Policy makers can see **what types of intervention would be necessary**: potentially by working with a powerful actor in the value chain, who can stimulate others actors to take steps, or by acting as a facilitator or co-ordinator, where no other organisation in the value chain has sufficient capacity or incentive to do so. The case study analysis illustrates that for complex consumer goods product sectors, such as mobile phones, the power within the supply chain to initiate innovations resides among a small number of original manufacturers not necessarily based within the EU. In the food sector, substantial power resides among large retailers as well as large some manufacturers where brand is a significant consumer issues. Within material sectors, such as steel and plastics, the power to initiate circular economy innovations resides among designers, architects and supply chain managers. These innovations are already being implemented in some product sectors, such as automobiles. Further potential exists within other sectors, such as construction, which would benefit from broader forms of coordinated support such as knowledge exchange and professional training.
5. Creating the right market conditions for value chain collaboration may need **changes to the market** - for example the extension of competition policy tools to reduce market power, or the creation of new incentives for co-operation through changes in market structure (for example, like Extended Producer Responsibility).
6. There may not be sufficient trust and incentives for the value chain to co-operate to realise an opportunity purely because of the **size of the costs of innovation**. In these cases, public innovation policy may help the value chain make a transition to greater circularity by lowering those investment costs, for example through subsidies or development of a technology.
7. Where policy is trying to promote value-chain co-operation, it may help to consider the notions of **referent power and expert power** (measures of the attractiveness of participation with an economic actor because of their image or their offer of expertise). Policy makers may be able to set up co-operation based around these forms of power. Public sector organisations themselves - even if only in their roles as brokers, or facilitators of co-operation, can display these types of power: and the way in which the public sector organisations develop or work with these types of power could be a success factor in co-operation for circularity.

It is not always easy to establish the power relationships within value chains. Interviews with participants appear to be the most likely route of discovery. Another metric - which particularly relates to coercive power - is the profit margin which the different firms in the value-chain can extract, as show in Table A, from Cox et al. (2000). It is an example for the UK convenience grocery market, with the reasonable assumption that higher profit margins indicate greater power.

Annex 6: Case study analyses of four prioritised circular economy areas

Table A- Metric of power relationship using profit margins

	Convenience Retailing	**Grocery Distribution**	**Grocery Processing**	**Raw Material Production**
Gross Profit Margin (return on sales)	20-25%	1-2%	6-10% without strong own-brand competition. 3-5% with strong own-brand competition	20-25% for crops within CAP. 1-3% for crops outside CAP

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Tang, C.S., and Zimmerman, J. "Managing New Product Development and Supply Chain Risks: The Boeing 787 Case". *Supply Chain Forum: An International Journal*. 10: 74-86. 2009 who also show wonderful hindsight in pointing out the problems that then materialised with this supply chain structure, on:

http://blogs.anderson.ucla.edu/global-supply-chain/2013/05/boeings-787-dreamliner-a-dream-or-a-nightmare-by-christopher-tang-based-on-work-with-brian-yeh-pwc-advisory-and-joshua.html.

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Annex 6: Case study analyses of four prioritised circular economy areas

1 Mobile phones and smart phones

1.1 Introduction

The purpose of this case study is to develop an understanding of the:

1. circular economy opportunities within the smart phone supply chain;
2. structure of the smart phone supply chain including the points of power and influence;
3. winners & losers within this system should transition or intervention occur.

This case study has opted to focus on mobile phones and where differentiation is useful, smart phones. Many of the findings will be very much in common with parallel supply chains such as other larger hand held devices (i.e tablets). Smart phones are a technological evolution of mobile phones and hand held devices such as tablets are most typically a scaled up version of smart phones which call upon much of the very same supply chain. From a user perspective, hand held devices such as tablets represent the near convergence of mobile phones and personal computers, although the structure of the two supply chains poses notable differences, having developed from different innovation routes.

Smart mobile phones in particular are an example of a high technological and often aspirational product. The product group shows some growing signs of consumer interest and participation within the circular economy in which consumers can express their pro-environmental identity through what their phones say about them. This is in the context of the product group in which some consumers have become aware of obsolescence and compatibility issues. Smart phones are also a product where image is an important sales feature, and source of profit margin. Smart phones therefore offer the prospect of being a pioneer product where there may be scope for intervention. The actions have been categorised as follows:

1. Better capture of end-of-use of handsets;
2. Cross-manufacturer standardisation of peripheries.
3. User led refurbishment of all durable items including batteries and covers. This is already the case for most mobile phones and smart phones, with the notable exception of Apple's iPhone which is not designed for the user to be able to access and therefore readily replace the battery.
4. Improved access and replaceability of main components. This could include:
    a. End-of-life refurbishment involving a move towards component design that makes the refurbishment (or recyclability) of handsets easier for those components which are most likely to need replacement at the end of life.
    b. In-use and user-led refurbishment using open source component modularisation. This concept has been characterised by the phonebloks concept[173] but might take a less extensive form.

1.1.1 Value in smart phones

One way to look at the opportunities for greater circularity in smart phones is to look at the value of the smart phone at different phases in its usable life, and the potential for value which is currently lost to be captured by an increase in circularity. For instance, the value of

[173] For further information on the phonebloks concept see: https://phonebloks.com/en/about

a phone with a failing battery is low: when that battery can be replaced, the value of the whole phone increases once more.

The figures below, show hypothetical, but plausible graphs of the value of a smart phone over time, showing events which reduce its value. The phone's minimum value is the recyclable material value, minus the cost of its recycling. This may be negative. But even if it is positive, from an economic, environmental and resource point of view, recycling of the share of material which can be recycled, is much lower than continued use of the phone, with all the embedded energy and resources which went into its production.

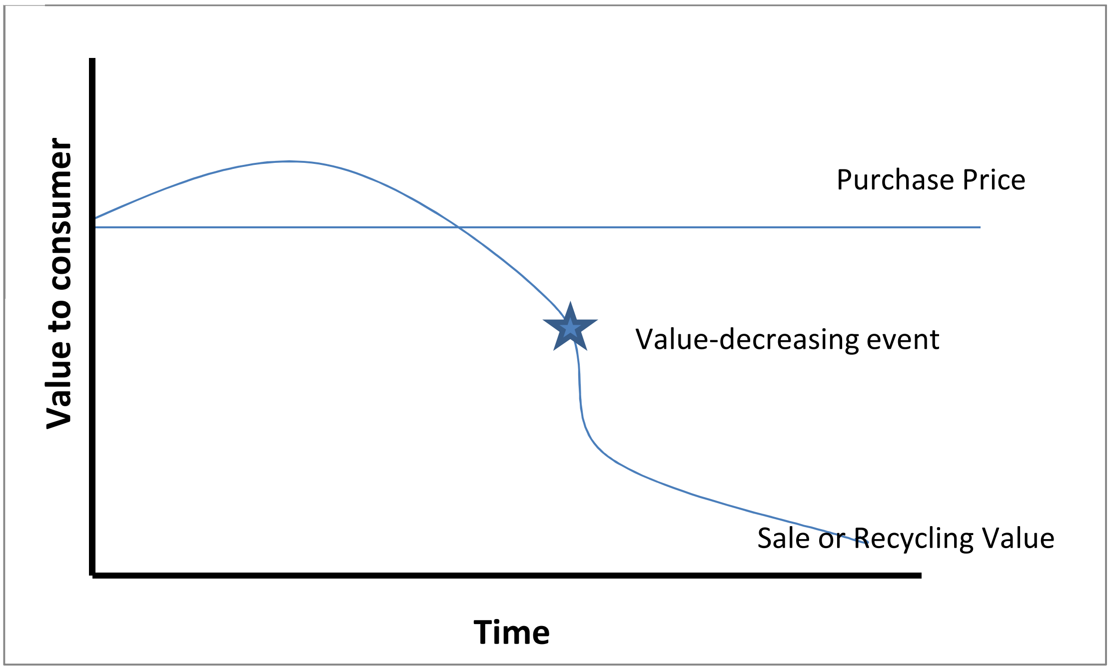


Figure 8: Value of a smart phone over time

The nature of a value-decreasing event (of which there might be more than one during the phone's life) can differ:

- battery failure,
- other functional failure,
- functional obsolescence due to standard changes or software upgrades needing greater hardware capability,
- fashion (or demand) obsolescence due to new model arrival with enhanced functionality,
- consumer hoarding of usable, or recyclable phones (whether for sale in the EU, or outside the EU - there are now estimated to be 7 billion phone contracts in the world: the second hand market for EU smart phones is likely to be strong)

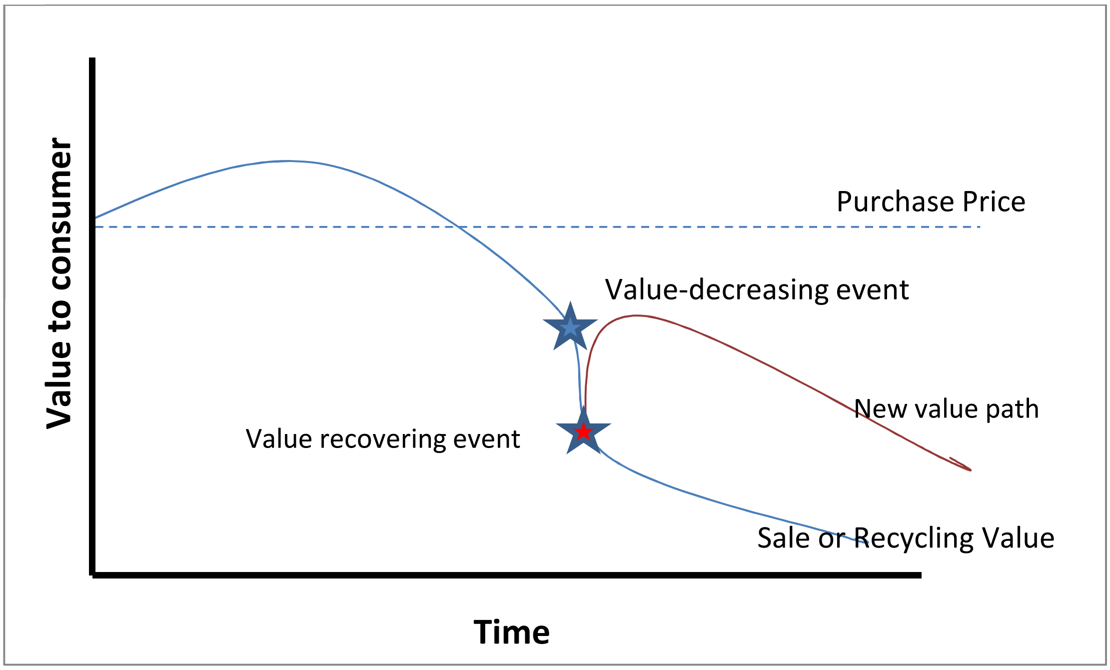


Figure 9: Saved value of a smart phone from a refurbishment shown by red line

Where, as shown in Figure 9, the 'lost' value of the smart phone can be captured, by an action such as a software update, battery replacement, or component replacement, and when that action is cheaper than the value saved, there is an opportunity for circular economy.

The circular economy can be promoted where that otherwise lost value can be captured, or better, where it can be captured and also increased. The various business and design innovations which have been categorised in this case study can achieve one or both of those. The capturing of value should benefit at least one of the parties in the value chain - perhaps the consumer, perhaps the reseller, refurbisher, or, in some cases, under some conditions, the producer.

Yet, it may be that the technologies already exist which would allow the consumers to maximise the value of their smart phones along its lifecycles, but that existing norms or practices prevent that value being realised. The transaction, or transition costs, from existing practices and technologies to alternative technologies and practices may be high (for example, the creation of infrastructures for phone recycling).

There may be non-economic barriers to change: that includes - for example - hoarding of working mobile phones - which could be sold into secondary markets.

There may also be business reasons that block transition; the profits of phone manufacturers are often not aligned with the maintenance of value of the phone for consumers, as phone manufacturer's benefit from the sale of new phones.

Transition to technologies and practices which capture value which is currently lost are likely to take place where it is possible to share that captured value amongst the economically and politically valuable actors in the value chain. To help assess that, this case study looks at winners and losers from options to capture value in smart phone which would otherwise be lost.

We assume that the drivers of actors in the supply chain (against which win/lose are judged) are profit maximisation, which is the product of profit margins and sales. It may be possible for sale volumes to decrease, where profits go up, and vice-versa.

1.1.2 The history of Europe and the mobile phone market

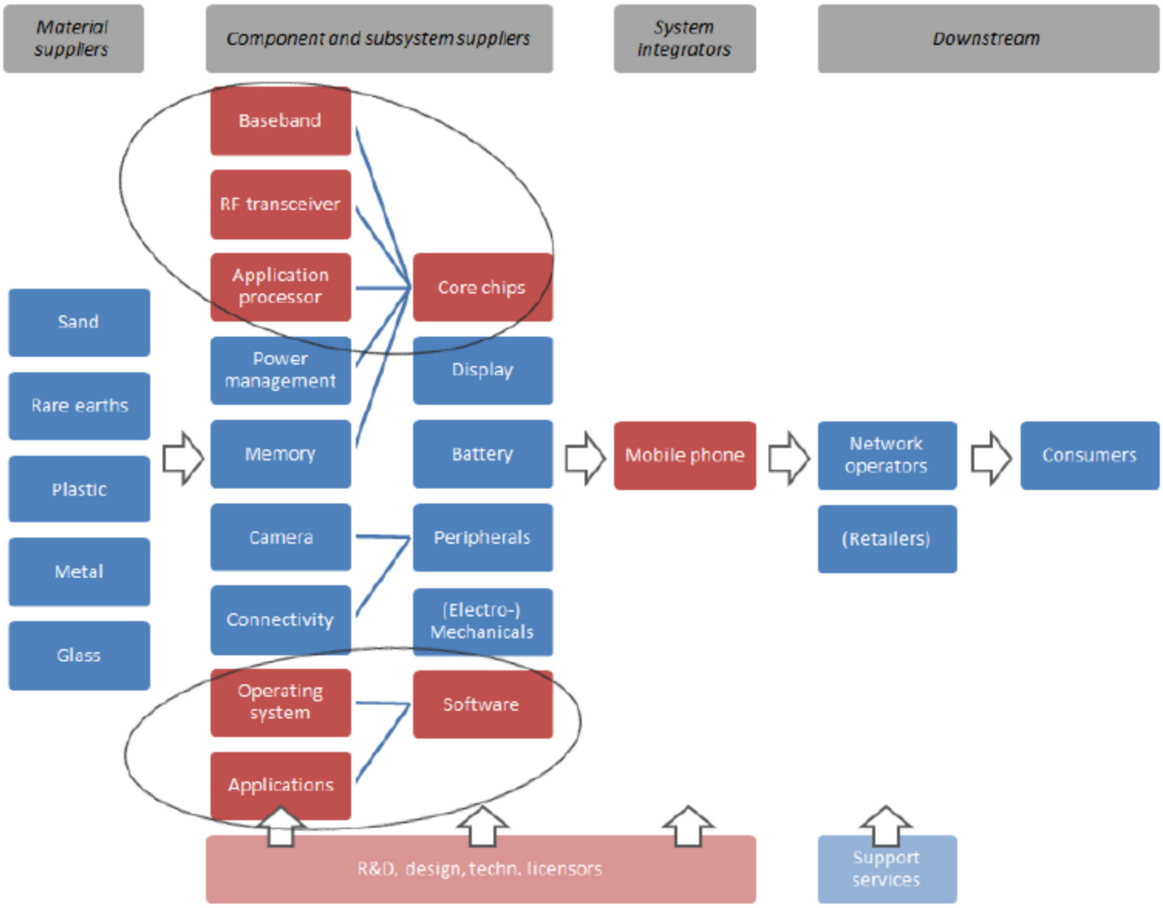
European mobile phone companies historically have been performing well with Nokia (Finland), Ericsson (Sweden) and Siemens (Germany) capturing around half of the global market as recently as 2004-2005. Moreover, French companies Alcatel and SAGEM also held significant shares of the market in the early 2000s. This historic positioning in the global market for mobile phones in large part can be attributed to the successful attempt at defining a European standard for digital cellular networks, which also quickly developed into the first world standard. Importantly, involvement in the development of the GSM (2G) standards enabled European companies to claim approximately two thirds (65%) of the essential patents for technology supporting the standard. European mobile phone companies have been struggling to survive in recent years. With Nokia being the only remaining European original equipment manufacturer (OEM) in 2012 and losing market share (24% in 2010 and down from 40% in late 2007). This decline has coincided with the emergence of smart phones where European OEMs have now lost out to their Asian manufacturers to compete with Apple and their iPhone in the smart phone market. Losing out in the smart phone sector also represents a more significant decline in profit for European OEMs than the share in total mobile phone sales would suggest.

1.1.3 Structure of the smart phone supply chain

The case study on Mobile Devices undertaken in 2012 by the Danish Technological Institute on the 'Internationalisation and fragmentation of value chains and security of supply[174]' provides a very extensive and relevant introduction to the consequences of internationalisation of component manufacturing within the sector. It describes in detail the way that the supply chain is organised, its evolution as well as who within it has power to coordinate change. The 2010 ICIP report 'The Distribution of Value in the Mobile Phone Supply Chain' describes the value distribution within the supply chain including the relationship and 'effective subsidies' paid by network operators to smart phone manufacturers in some countries. There are various different business models for the supply of smart phones to consumers. Often, smart phones are offered either 'free' or at reduced cost by mobile network operators or retailers together with an ongoing contract for telephone services. Consumers can often buy smart phones at full price, and use those on lower value contracts. The structure of the mobile phone value chain is presented in Figure 10and summarised in Box 1.

[174] Published 17th February 2012 within the Framework Contract of Sectoral Competitiveness Studies ENTR/06/054,

Figure 10: Structure of the mobile (smart) phone value chain



Source: Danish Technology Institute 2012

Box 1 - Structure of the global mobile phone value chain

Competition is increasing in the smartphone market as established players as well as new entrants look to move up from the low-end and mid-markets to get their shares of the greater profits in this supply chain. Overall, the mobile phone industry, much like the PC industry, has gone through a phase of unbundling and fragmentation followed by partial consolidation and vertical integration as the technology has become both more standardised and sophisticated, and specialisation benefits and cost pressures set in. Thus, most of the established players in the industry at some point were involved in the manufacture of everything from basic components to the wireless networks on which the mobile phones run. This is no longer the case, as the industry has not only split into components, design, assembly, software and networks, but also into an increasing variety of components and software and more layers of manufacturing and assembly functions provided for by different companies.

Competitive pressure on traditional OEMs to try to reduce size or footprint has resulted in the greater outsourcing to the wider value chain of manufacturing, assembly and testing and in some cases even design functions. This has largely followed model set by the PC industry. Nokia has been the exception to this by keeping some of these production stages in-house. This was previously key to staying ahead of its competitors by maintaining greater flexibility and offering a wide range of phones built on the same base but adapted to the characteristics of regional markets. There has also been a move towards the component suppliers becoming vertically integrated first tier suppliers of whole component units. Therefore, OEMs have been moving from being a purchasing organisation buying single components directly from a range of individual suppliers varying from region to region, to a sourcing organisation increasingly demanding first tier suppliers to provide whole sub-systems solutions and establish a presence in every region where it has a presence. This provided economies of scale but also presented a barrier for new entrants and therefore a potential erosion of profit and market power. Some OEMs have guarded themselves from this risk by only outsourcing non-strategic parts of the value chain and Apple is understood to be buying its way back into manufacturing its own processor chips partially for this reason.

Overall though, in terms of the smart phone market at least, fragmentation has enabled economies of scale in the manufacture of the most standardized components such as core processors, radio frequency transceivers and amplifiers, power management, memory, displays and batteries. With regards to memory chips, display panels and batteries, most if not all suppliers come from Japan, Taiwan, South Korea or China. The detailed structure of all of these supply chains are explored in detailed as follows:

- **Mobile chip manufacture:** The manufacture of baseband chips (i.e. the chip or part of a chip that manages all the radio functions such as Wi-Fi and Bluetooth) is becoming increasingly concentrated. The American owned companies Intel and Nvidia acquired German owned Infineon Wireless and British owned Icera in 2010 and 2011, respectively. This leaves American owned Qualcomm, Intel, Nvidia and Broadcom; and Taiwanese owned MediaTek, Japanese owned Renesas and maybe ST-Ericsson as long-term suppliers of mobile baseband processors, only one of which is European. More concentration and less differentiation are expected in this market in the coming years due to the costs of research and development. The further trend of integration of transceiver and baseband in a single chip (i.e. radio frequency chips) provides one way of optimization of power usage and is therefore critical to the performance of high-end phones.
- **The mobile memory** market is dominated by South Korean Samsung capturing nearly half the market (IHS iSuppli data). Together with American Micron and South Korean Hynix (previously Hyundai Electronics), this is the only company presently with the capabilities to offer multichip memory combining DRAM and NAND flash by itself.
- **The mobile battery** market was almost as concentrated as the mobile memory market in 2012 with Japanese incumbents Sanyo (owned by Panasonic (previously Matsushita)) and Sony and upcoming South Korean Samsung and LG Chem accounting for close to three quarters of all rechargeable lithium ion and polymer batteries sold.
- **The mobile display market** overall is less concentrated than the mobile memory and battery markets. However, in this market too South Korean Samsung is a prominent player, especially when it comes to AMOLED displays for which only a handful of significant suppliers exists. In contrast, there are at the moment over ten suppliers of the more common LCD displays with notable market shares. The only active

European company in the display market, Dutch Liquavista (spun off from Philips in 2006), was acquired by Samsung in 2010.

Source: adapted from Danish Technology Institute 2012

1.1.4 Detailed opportunities for greater circularity

There are a large range of opportunities for actions which improve environment performance and promote greater circularity in the mobile phone and smart phone value chain. A pilot project led by Nokia (Singhal 2006)[175] resulted in the setting up of five environmental initiatives which have the potential of eliminating a very large portion of life-cycle environmental impacts of mobile phones. These covered:

1. Information and Communication;
2. Reduce Energy Consumption in Use Phase;
3. Reduce/Eliminate Agreed Materials of Concern;
4. Take-back of Phones;
5. Environmental Assessment Methods to be used to standardise a practical eco-design approach across the sector.

These initiatives provide the foundation for further actions which are more specifically focused on product circularity in a way that engages consumers in the circular economy and that policy potentially has a role to play to support these initiatives. Based on this, the following actions have been identified:

1. Better capture of end-of-use of handsets.
2. Cross-manufacturer standardisation of peripheries.
3. Replaceability of all durable items including batteries and covers.
4. Better design for refurbishment and reparability and recyclability of all main components. This could include:
    a. End-of-life refurbishment or recyclability.
    b. In-use and user-led refurbishment.

The potential alternative options for these, and their implications for winners and losers are explored in turn below.

Better capture of end-of-use of handsets.

This action has several possible alternatives:

1. Network operator take-back schemes with a deposit incentive as part of phone contract. This would allow capture rates to be greater than under voluntary schemes as the deposit value can be set higher than the value of the likely end-of life value of the handset for low value handsets.

[175] Singhal. P, Integrated Product Policy Pilot on Mobile Phones Stage IV Final Report: New Environmental Initiatives & Experiences from the pilot, Copyright Nokia Corporation 2006 - http://ec.europa.eu/environment/ipp/pdf/final_report_mobile.pdf

2. Handset rental contracts which require the return of the phone to the provider who maintains legal ownership throughout the life of the contract.
3. Promotion of handset recycling schemes at the point of sale. These schemes are market based initiatives[176] which take for free or pays money for all end-of-use handsets. This would likely be achieved by all new phones sent to consumers being sent envelopes for such schemes and all sales reps required to take old phones at the point of sale.

Figure 11: Possible winners and losers under better capture of end-of-use of handset alternatives

<table>
<tr><th></th><th>Capture rate</th><th>Consumers</th><th>Network operators</th><th>Handset supply chain</th></tr>
<tr><td>Network operator take-back schemes with deposit</td><td rowspan="3">Very good</td><td colspan="2">Some possible resistance due to increase in total financial commitment within contract values</td><td>Possible concern over reduced sales of new phones - depending on destination of captured handsets</td></tr>
<tr><td rowspan="2">Handset rental contracts</td><td colspan="3">Possible devaluation of handsets value within contract negations</td></tr>
<tr><td>Resisted: Possible data security issues, desire to own products & possible requirement to take insurance.</td><td>Might resist due to lack of incentive for consumers to return handsets</td><td rowspan="2">Possible concern over reduced sales of new phones - depending on destination of captured handsets</td></tr>
<tr><td>Promotion of handset recycling schemes at the point of sale</td><td>Good: lower for low value phones</td><td>Ensures consumers capture end-of-life value of handset</td><td></td></tr>
</table>

Key:

Winner or not a loser
Possible or slight loser
Loser

Cross-manufacturer standardisation of peripheries

There are a number of attachments and peripheries which can be standardised across the sector. Standardisation is an established process within the electronics sector generally. A standard will typically be initiated by the market leader and followed by others who wish to reduce competition barriers that they face. This will differ when the market leader is able to establish property rights over its standard in some way and therefore present a barrier to competition. In these cases, the market leader will be incentive to maintain this barrier so

[176] Such as for example in the UK: FoneBank, Envirophone and Mobile Phone Xchange

long as this incentive remains. This could occur if a number of the other manufacturers agree a standard among themselves.

The most notable periphery used for smart phones is the charger which is already in the process of standardisation and acts as an example where consumer's wider interests outweighed the more narrow interests of some manufacturers. Incompatibility of chargers for mobile phones is not only a major inconvenience for users, but also an environmental problem. Users who want to change their mobile phones usually have to acquire a new charger and dispose of the old one, even if it is in good condition. In addition, the lack of standardisation will require users to carry their charges with them more often as access to compatible charges is less likely. In response, the Commission invited manufacturers to agree on a technical solution making the chargers of different brands compatible and world leading mobile phone producers committed themselves to ensure compatibility of data-enabled mobile phones, on the basis of the microUSB connector. The agreement was signed in June 2009 by Apple, Emblaze Mobile, Huawei Technologies, LGE, Motorola, NEC, Nokia, Qualcomm, Research in Motion (RIM), Samsung, SonyEricsson, TCT Mobile (ALCATEL), Texas Instruments and Atmel (IP/09/1049)[177]. This represents more than 90% of the mobile phone sales in Europe.

The assessment of winners and losers has been undertaken for this measure retrospectively to illustrate some of the issues involved with standardisation.

Figure 12: Winners and losers under standardisation of mobile phone charges (example)

	Non-Apple smart phones		Apple iPhone	
	Manufacturers	**Consumers**	**Consumers**	**Manufacturers**
Standard use of microUSB chargers			Loss of brand differentiation	
			Reduced functionality and standardisation across their global product range	
	Cheaper purchases and replacement chargers			Loss of revenues from replacement chargers
	Convenience of being able to charge phone at more locations			

[177] For further information about the agreement see: http://ec.europa.eu/unitedkingdom/press/press_releases/2010/pr10134_en.htm

	Reduced barriers to brand switching		Reduced market barrier to their consumers switching
			Maintained brand reputation in face of consumer pressure

Key:

Winner or not a loser
Possible or slight loser
Loser

Apple was the most notable of phone manufacturers to have maintained their use of different chargers and connectors. For its most recent smart phone, the iPhone 5, Apple developed the 'Lightning connector' which is in common with its' laptops and is said to offer 'faster file transfers' when plugged into a laptop, and can be inserted either way up, unlike the microUSB. An update in Apple's smart phone operating software, iOS 7, prevents users from charging their phones using non-Apple chargers. This system therefore could be said to offer Apple consumers some additional functionality not offered by the industry standard microUSB and also some brand differentiation which arguably benefits both Apple and its consumers. As explored in Figure 12, this situation also allows for additional revenue via sales of replacement charges from their retail outlets. In some ways though, the interests of Apple and its customers are not aligned as more standardisation offers Apple consumers more convenience and cheaper purchases and replacement charges. The market-based incentive for Apple to engage in standardisation therefore is limited to the extent that their existing consumers are willing to switch to other brands due to these kind of issues.

Replaceability of all durable items

This action included batteries and covers a great many similar issues as the standardisation action. User led refurbishment is already the case for most mobile phones and smart phones, with the most notable exception of Apple's iPhone which it is not designed for the user to access and therefore readily replace the battery. This arguably represents an example of designed obsolescence as there is an additional barrier to long-life as the battery reduces in functionality and requires the additional cost of manufacturer led replacement if the phone is outside of its warrantee. An assessment of winners and losers has been undertaken for the action that users be able to access and replace the batteries on all mobile and smart phones.

Figure 13: Winners and losers of user-led replacement of batteries (Apple iPhone case study)

	Apple iPhone	
	Consumers	**Apple**
User-led replacement of batteries	Possible loss of enclosed presentation of product	
	Cheaper out-of warrantee battery replacements	Loss of revenues from charges to replace batteries
	Longer life of products and therefore saving of money for most consumers	Reduced long-term sales
	Maintained brand reputation and market share in face of consumer pressure	

The enclosing of batteries and other components offers an easy and cheaper way to deliver the consumer a neater and more streamlined product. It also offers increased income from non-user-led replacements. Perhaps more significant an issue is the increased long-term replacement sales from committed customers due to the premature and economic obsolescence of handsets in which the battery has reduced in effectiveness. This needs to be weighed against the improvement in market share and brand reputation if this issue is to be resolved.

Improved access and replaceability of main components

The options under this action could include:

a. End-of-use non-user-led refurbishment involving a move towards component design that makes the refurbishment (or recycling) of handsets easier for those components which are most likely to need replacement at the end of the use of the phone by a consumer. This option relies heavily on which option is taken under the action 'Better capture of end-of-use of handsets'.
b. In-use and user-led refurbishment using open source component modularisation. This concept has been characterised by the Phonebloks conceptual vision[178] in which the user should be able to upgrade the display independently of the CPU, independently of the graphics, independently of the RAM, independently of the Bluetooth, and so on. It is possible that this action might take a less extensive form.
c. Design for extended warranty is a hybrid system that seeks to encourage a systemic re-design which encloses the components but re-designs their layout and accessibility in a way that allows for easier refurbishment and greater in-life repairs (user-led or otherwise). The change here is brought about by incentivising OEMs to ensure that handsets are economically repairable over a longer period.

[178] For further information see: http://www.fastcodesign.com/3017409/why-lego-design-principles-dont-work-on-smartphones

There are a number of factors that limit the extent that modern mobile phones and smart phones in particular can be designed in a way that some individual components can be replaced under either of these actions:

1. Some components in smartphones are integrated as the distance between components can slow the function of the handset. Therefore smartphones designers tend to put as many components as possible on a single chip. To illustrate, the iPhone 5S's processor integrates CPU, graphics and RAM together in a sandwich-like arrangement. To re-divide these risk making smart phones larger and consume more power.
2. Existing OEMs have limited incentives to design for refurbishment. Technological innovation means that the value of handsets more than a few years old is diminished by the availability of newer and improved models. Furthermore, consumers apply high discount rates when making investments in consumer goods and value benefits now greatly over future benefits. Therefore, there is limited value in the mind of many consumers at the point of sale in a handset being refurbishable. Finally, OEMs risk forgoing sales of higher value new phones if the refurbished phones are acceptable to its high value consumers. One way that OEMs can tackle this risk is to take charge of the capture schemes and seek to direct the refurbished phones to their lower value consumers, perhaps outside the EU[179].

The phoneblok concept seeks to tackle at least some of the issues raised in the second point by explicitly involving the consumer in a visual way with in-life user-led reparability and upgradability. In addition to the general limitation raised in the first point above, the phoneblok design in particular raises some further issues[180]:

3. Phonebloks would require additional costs of sockets etc. so that the CPU, graphics, RAM, storage and modem for example could communicate with one another at high speed.
4. The additional encasing required for each component risk leading to greater use of materials throughout the lifecycle of the handset.

Many of these issues may be dealt with by a hybrid system that encloses the components but re-designs their layout and accessibility in a way that allows for easier refurbishment and greater in-life repairs (user-led or otherwise).

There can be considerable attachment by consumers to their existing phones in the less tech-savvy segments of consumers. These consumers may also have no need for many of the features on smart phones, particularly the newer features which increase the sales of new phones. However, these non-tech savvy consumers can still be fashion conscious. The combination of these trends may mean that there is a market for phones which can be updated, and which have some viable 'cool' justification for not being the most modern model (in this case the 'green' benefits).

[179] This risks the loss of material if the eventual disposal occurs in a country with less stringent regulations on the disposal of WEEE.

[180] For further information see: http://www.fastcodesign.com/3017409/why-lego-design-principles-dont-work-on-smartphones

Yet, it seems that there is no incentive for the existing market leaders to pursue this market, perhaps because higher profits are being made (both for the OEM and the phone retailer) from new smart phones.

We have not explored the motivation for purchasing of smart phones: it may well include strong reliance on brand, and popularity of brands, because of uncertainty about performance and reliability of phones. However, there may be a case for non-market leaders to appeal directly to those consumers who value repairable and longer life handsets, particularly where they tackle uncertainty, for example by offering manufacturer warranties that guarantee use for maybe 3-5 years, or, perhaps, an update service.

This would incentivise these OEMs to make diagnosis and repairs be as simple as possible and user-led whenever practical. This would offer the OEM access into the competitive smart phone market and potentially access components manufacturers, many of whom have gained horizontal market power as a result of developing larger component units. Legal requirements for such extended warranties would lead to this innovation across the sector but would likely be resisted by OEMs who have an established or dominant market position.

The winners and losers of these options are assessed in Figure 14 below.

Figure 14: Winners and losers of different access and replaceability scenarios

<table>
<tr><th></th><th></th><th></th><th colspan="3">Handset value chain</th></tr>
<tr><th></th><th>Consumers</th><th>Network operators/Handset retailers</th><th>Dominant OEMs</th><th>Non-dominant OEMs</th><th>Components suppliers</th></tr>
<tr><td>End-of-life non-user-led refurbishment</td><td>Possible access to cheaper refurbished handsets</td><td>Possibly excluded from refurnished market</td><td rowspan="3">Risk of reduced volume of high value sales of new phones</td><td rowspan="3">Opportunity to innovate and access market</td><td>Innovation required</td></tr>
<tr><td>In-use and user-led upgrades</td><td>Higher upfront costs</td><td rowspan="2">Reduced sales</td><td rowspan="2">Innovation required but opportunity to sale directly to consumers</td></tr>
<tr><td>Design for extended warranty</td><td>Lower long-term costs</td></tr>
</table>

Key:

Winner or not a loser
Possible or slight loser
Loser

In terms of who possesses the power and influence to initiate this action, the OEMs seem to be the actor who is necessary to initiate change. Component manufacturers represent an important player, although in most cases do not possess the market power within the vertical supply chain. In theory network operators are the player that has the position to call for change, although in reality it is the OEMs who appeal to consumers via network operators who hold the power in this regard. The power of OEMs is limited by what consumers are actually willing to pay for in what is a competitive market.

Therefore, as shown in Figure 14 above, it is the established and dominant OEMs who are in a position of power and who have the potential to lose from this action. Handsets that allow improved access and replaceability of main components risk reducing their level of overall sales of new units. This can be mitigated if they ensure that refurbished phones are diverted from their high value consumers. Figure 14 also suggests that less dominant and emergent OEMs have less to lose from greater reparability and may well have more to gain by gaining market position. The potential benefit of this innovation is limited to the extent that the innovation appeals to the consumer, and that the consumer benefits from it in a way that the consumer can understand. Therefore, it is likely that the third innovation scenario '*Design for extended warranty*' offers the most advantageous innovation for them to pursue. This scenario also potentially enables some component manufacturers to bypass the existing dominant OEMs and sale unitised components directly to consumers.

The role of policy in this action seems best targeted at the length of warranty. This would be made considerably easier if an OEM could form alliances with component manufacturers and demonstrated that the innovation is possible.

1.1.5 Power, influence and innovative capacity within the value chain

The description of the evolution of the value chain for smart phones illustrates some of the ways that power and influence is distributed across the mobile phone and smart phone value chain. The smart phone value chain appears to be one where there is a reasonable balance of power between actors along the supply chain - for example between the OEMs and the component suppliers. It still appears that the actor who is most central in initiating change in the handset value chain are the OEMs who commission and direct component manufacturers to innovate. However, within this system, some component manufacturers are gaining a more dominant market position as they produce larger and more complete components, and they can also be centres of innovation. One aspect of the power balance has been shown by the Intellectual Property battle between Apple and Samsung. Samsung are one of the main component suppliers to Apple, whilst also being their main competitor for the smart phone market.

Brand - and so related design, marketing and reputation issues - play a crucial role in maintaining profit margins for the leading OEMs and in maintaining their power and profit capture over the value chain. This might not always be possible in future as consolidation and specialisation within the supply chain has become necessary to respond to the pressures to innovate.

The smart phone value chain displays many of the features which would allow it to innovate for the circular economy: there is a balance of power between relatively few actors within the value chain: those actors have high innovative ability; the actors also frequently work with each other to plan and co-ordinate innovations, to create whole innovative products; as the number of actors is small, there are ongoing relationships between the market players, which facilitate trust and pay-back on innovation.

That indicates that, if the economic incentives were in place, for at least some of the economic actors, this market could innovate towards greater circularity. The win-lose analysis above indicates some of the political issues which might lead to blocks in policy efforts to do that.

We also need to consider consumers, both in purchasing and in end-of-use behaviour. Consumers potentially possess the most significant influence over the value chain in shaping the design of phones they use. However, their choices are shaped by the phones on offer, not least when network operators sell them the handsets within use contracts, and who have their own economic interests vis à vis both consumers and OEMs. Dominance of the main retail outlets for mobile phones may limit innovation for the circular economy, where it is not in the retail/outlet's interests. Underlying the latter issue is what is really driving consumer choice at the point of sale, and so profit margin. So for example, whilst as a citizen may exert pressure for certain pro-environmental innovations to occur, as a consumer making a final purchasing decision the factors driving the decision may well be more focused on the handset’s functionality and identity statement. This will likely lead to sidelining of the full life cycle issues considered in this case study as consumers reduce the complexity of the decision to the most immediate factors. It might therefore be argued that policy has a role to play to exert influence within the value chain to coordinate sensible and cost effective measures on the consumer’s behalf which promote greater circularity.

2 Metals and the transition to use of high-strength steel

2.1 Introduction

The iron and steel sector is a highly energy intensive sector. There has already been significant and on-going effort within the upstream sector in reducing the energy use within the production of iron and steel. This case study therefore focuses on the optimal use of metals (and steel in particular) within value chains. There are two strategy areas reported in the literature to achieve this:

1. The better design of products to use less steel.
2. The greater use of high strength steel.

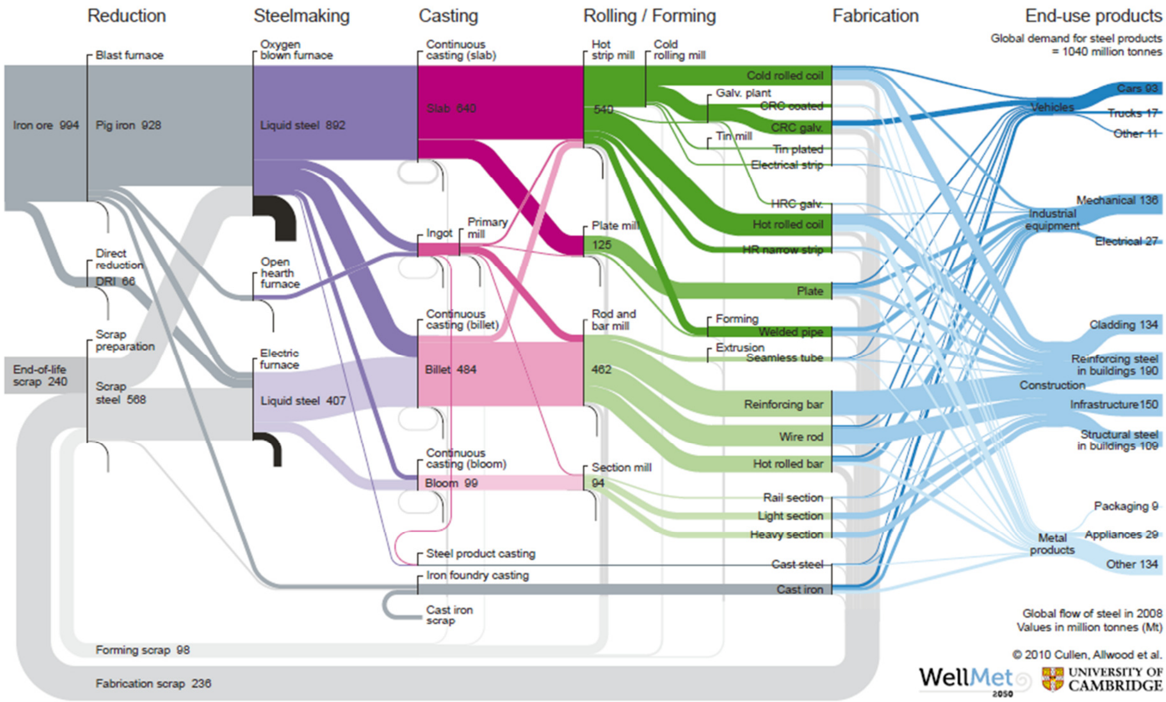
These changes require corporations to occur vertically along the various supply chains which use steel. The optimal use of steel in value chains represents a strong case study as its application is relevant to a number of sectors identified as priority circular economy areas within the project's prioritisation exercise, in particular, the construction sector and automobile industry.

2.2 Structure of the steel value chain

The existing iron & steel system is a highly complex system involving numerous production stages which all add value in a series of value chains. The value chain is characterised by the production of a series of commodity based intermediary products intended to be used in a very wide number of sectorial applications. The system as a whole has established recycling systems in place and manages to retain the purity of the steel within the system without the need for cascading material value.

2.2.1 The upstream steel sector

Figure 15: Global iron and steel system



Source: Cullen, Allwood et al., 2011. Going on a metal diet, WellMet2050

There are two main processes within the upstream steel production:

1. The EAF process uses steel scrap as its basic feedstock material. Scrap from old vehicles, appliances, industrial waste and domestic recycling is melted in large electric furnaces. Impurities skimmed from the liquid steel and chemical additives are introduced to bring the steel to its desired metallurgical balance. The recycled content of structural steel produced using the EAF process averages near 90%.
2. The basic oxygen furnace process used to make steel plate or rolled sheet steel is the more traditional method using iron ore and coke. Iron ore is melted in a coke (a processed form of coal) fired blast furnace and then transferred to a ladle. The molten iron in the ladle is chemically pre-treated and introduced along with steel scrap into the basic oxygen furnace where the entire mix is melted together while oxygen is introduced into the middle of the mix through a water-cooled lance. The molten mix is then poured into a ladle for rolling into sheet or plate. The recycled content of steel produced using the basic oxygen furnace process is typically 25%.

Consolidation is a major factor in the iron & steel sector. The world's biggest steelmakers are continuously investing to buy smaller competitors to achieve economies of scale and market share. Notable examples include Kawasaki and NKK of Japan forming JFE Steel, Thyssen and Krupp of Germany merging into Thyssen-Krupp, British Steel and the Netherlands' Royal Hoogovens becoming Corus, and three major European steelmakers consolidating into Arcelor. Lakshmi Mittal built a steel empire, by acquiring poorly performing steel plants in 14 countries across the globe and incorporating them into a more efficient company. In October 2004, Mittal Steel, acquired the International Steel Group for

$4.5 billion to become the largest steel producer in the world. The company then made the largest-ever steel acquisition in 2006 when they took over Arcelor for $33 billion, becoming ArcelorMittal.

The pressures on the iron & steel industry to innovate are considerable. Steel users are demanding shorter delivery lead times, while steel producers are facing increasing business and planning complexity due to growing market demand for more complex steel products, which is driving up production lead times and the need for higher inventory levels. Additionally, many steel producers now have longer and more complex internal and external supply chain processes, including the use of subcontractors, which makes it very difficult to manage and coordinate along the supply chain.

2.2.2 The uses of steel

In steel manufacturing, a product can be classified into one of hundreds of grades; rolled into almost any combination of width, thickness, and length; finished to any number of specifications. The value chain structure of two prioritised sectors (structural and the automobile industry) are explored below.

The use of structural steel in the construction sector

The construction sector currently accounts for nearly half of global steel consumption. The use of structural steel is widespread, most particularly in commercial buildings. The four distinct components of the structural steel industry supply chain are:

1. **Producers** of structural steel products including hot-rolled structural shapes (wide flange beams, plate, channels and angles) and manufacturers of hollow structural sections (formerly known as tubular steel).
2. **Service Centers** that function as warehouses and provide limited pre-processing of structural material prior to fabrication.
3. **Fabricators**: Structural Steel Fabricators that physically prepare the structural steel for a building through a process of developing detailed drawings (the work of a detailer) based upon the construction drawings provided by a structural engineer; material management; cutting; drilling; shop fitting (bolting and welding); painting (when required); and shipping.
4. **Erectors** that construct the structural steel frame on the project site by bolting and field welding structural steel components together according to the construction documents.

The use of steel in the automotive industry

The automotive industry is the world's largest single manufacturing activity. It uses 15% of the world's steel, 40% of the world's rubber and 25% of the world's glass. It also uses 40% of the world's annual oil output[181]. It incorporates hundreds of companies making

[181] Suthikarnnarunai (2006) Automotive Supply Chain and Logistics Management. Retrieved from: http://www.iaeng.org/publication/IMECS2008/IMECS2008_pp1800-1806.pdf

thousands of parts and components that ultimately are integrated into a single plant that performs the final assembly.

The automobile sector has already undergone considerable innovation to develop and utilise high-strength steel alloys. The body of modern passenger cars already contains up to 80% high-strength steel and there is the potential to reduce the weight of vehicles by a further 20 to 25% through a combination of design optimization and using high-strength steel (Thompson 2011)[182].

2.3 Circular economy opportunities within the value chain

This case study has opted to focus on the optimal use of steel in value chains. There are two strategy areas reported in the literature to achieve this:

1. The better design of products to use less steel.
2. The greater use of high strength steel.

2.3.1 The better design of products to use less steel

Allwood *et all* (2011) explored how the same final service could be delivered with less metal. They identified four strategies; avoiding over-simplification; selecting the best materials; optimising whole products; and optimising individual components. The report found that better design could reduce the need for metal production (steel and aluminium) by a third, and the reduction of losses in manufacturing by a further quarter. The principles of light-weight design include to:

1. Support multiple loads with one structure;
2. Specify the loads correctly;
3. Align components with the loads as much as possible;
4. Choose the best material; and
5. Optimise the cross-section of any component which is subject to bending.

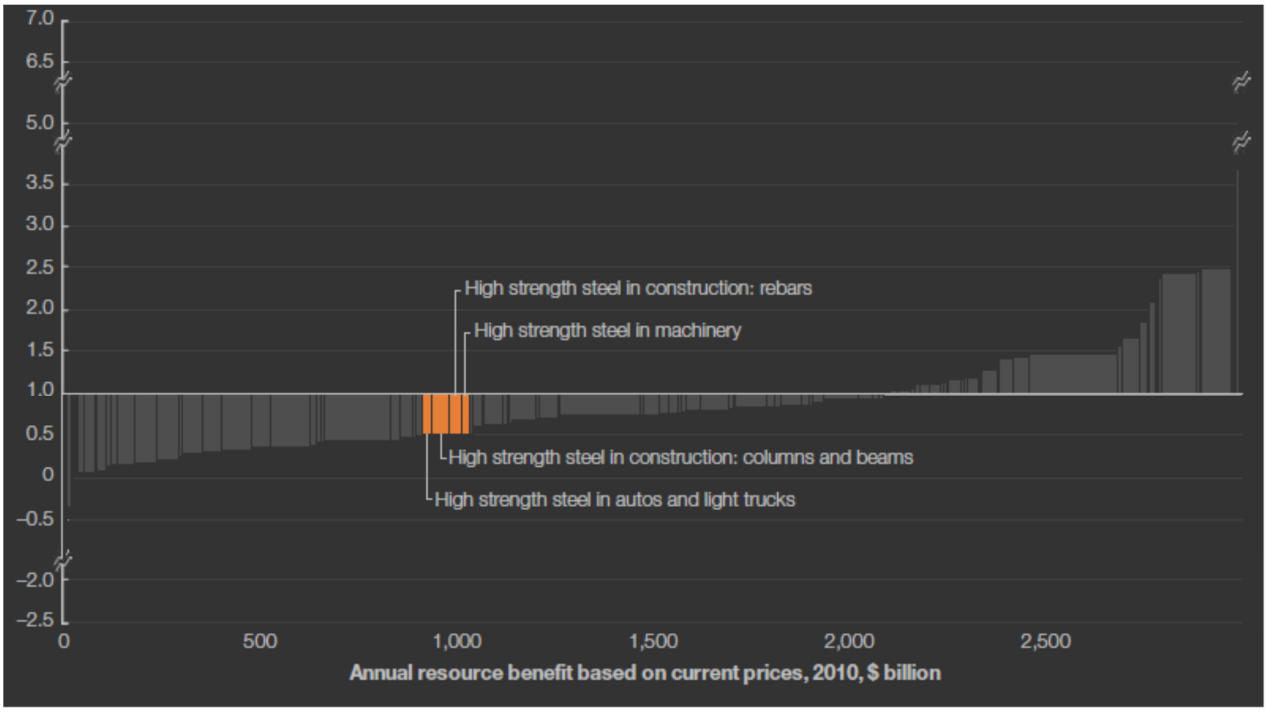
The focus was on using less metal but the reported benefits include fuel efficiencies for applications such as automobiles where weight is an important factor.

2.3.2 The use of high-strength steel

The McKinsey Global Institute (Thompson2011) explored the resource productivity cost curves for 15 areas of the global economy that comprise most of the potential benefits. It identified the use of high-strength steel (see case study box below) as one of the properties with a positive return on investment for a private investor. In particular, Figure 16 shows that four applications are cost effective. These include use of high strength steel in: construction (rebars); machinery; construction (columns & beams); automobiles & light trucks.

[182] http://www.imoa.info/molybdenum-uses/molybdenum-grade-alloy-steels-irons/high-strength-low-alloy-steel.php

Figure 16: Private cost effectiveness of investment in high-strength steel – ratio of investment to benefit



Source: Thompson 2011

The potential resource benefits identified in Figure 16 come from increased use of high-strength steel within the construction, machinery, and automotive sectors. These account for 80% of global demand. There's an opportunity to reduce annual steel demand by 165 million metric tons in these sectors by 2030 by optimising designs and increasing use of high-strength steel. Out of this total, Thompson 2011 estimated that about 21% is readily achievable:

- The construction sector currently accounts for nearly half of global steel consumption. Buildings such as the Shanghai World Financial Center and Emirates Tower in Dubai have already adopted high strength steel. Apart from saving on steel, using this technology reduces the CO2 emissions during construction by an estimated 30%. Savings in the EU from the adoption of high-strength steel are smaller than the global potential, as the EU already uses higher strength steel for many construction applications (for example, concrete re-enforcement bars). There is nevertheless very significant potential from the steps proposed by Allwood et al.
- In the automotive sector, substantial research has demonstrated a potential to reduce the weight of vehicles by a further 20% to 25% through a combination of design optimization and using high-strength steel. Even with currently proven technology, realizing the potential weight savings could save 35 million metric tons of regular steel by 2030.
- Machinery, theoretically, has a similar potential to reduce weight, but thus far lags behind the auto industry because fuel efficiency concerns are relevant for only a few types of mobile machines, such as cranes. If we draw on historical trends in weight reduction in the automotive sector, we estimate that the machinery sector could save 25 million metric tons of steel by 2030 by increasing the use of high-strength steel.

Although the economics of adopting high-strength steel are favourable, there is some doubt about whether materials such as manganese will be available in sufficient quantities to use them in alloys.

Case study Box: High-strength steel

High-strength (low-alloy) steel is a type of alloy steel that provides better mechanical properties or greater resistance to corrosion than carbon steel. High-strength steels vary from other steels in that they are not made to meet a specific chemical composition but rather to specific mechanical properties. They have a carbon content between 0.05–0.25% to retain formability and weldability. Other alloying elements include up to 2.0% manganese and small quantities of copper, nickel, niobium, nitrogen, vanadium, chromium, molybdenum, titanium, calcium, rare earth elements, or zirconium Copper, titanium, vanadium, and niobium are added for strengthening purposes. High strength steels are: stronger and tougher than ordinary carbon steels, more ductile, formable, weldable and resistant to corrosion. Because of their higher strength and toughness High-strength steels usually require 25% to 30% more power to form, as compared to carbon steels.

They are used in applications such as cars, trucks, cranes, bridges, roller coasters and other structures that are designed to handle large amounts of stress or need a good strength-to-weight ratio. High-strength steel cross-sections and structures are usually 20% to 30% lighter than a carbon steel with the same strength. High-strength steels are also more resistant to rust than most carbon steels.

2.4 Barriers to reducing the use of steel

Some actions can be taken to reduce the use of steel without any changes to the nature of the steel used: these are held back purely by issues with the designers and architects. There are also changes to design to reduce the use of steel, which rely on the use of different specifications of steel: these can also, sometimes, be held back by mismatches between the steel being offered, and the alternative use it is put to. These actions are then held back by issues in interactions along the whole value chain.

2.4.1 Demand side issues

It appears not to be the end-user of steel who usually has both incentives and influence over the use of steel in final products (like buildings). Rather, it is the designers, architects and value chain managers who exert the greatest reach and influence over product design and so the use of steel in various value chains. For final users, the amount of steel is usually neither reflected in the value of the cost of the product.

The incentives for these design actors to reduce the amount of steel are often low, compared to the perceived costs and risks of change. For example, an architect has very little incentive to reduce steel in the design of a building, particularly as their fee may be based on a percentage of construction cost. We have also heard that the relative financial saving from redesign of construction elements to reduce steel for most buildings is relatively small. In comparison to the costs of the architect's time, the saved steel may be worth 30 minutes of the architect's work. The architect may need to retrain to recalculate loads for a building with 'non-standard' structural support, or at best take some time to become familiar with new numbers and calculations. This appears not to pay off for the client or the architect. Even if architects were able to charge the client for the extra time that the change in their work took, the client would seem not to profit. In practice, architects may not charge by time, but by a percentage of cost.

There are also incentives to over-specify loads, to make up for potential calculation errors (which would bring significant costs).

Similar issues appear likely for design of products, where the amount of steel used is not an important factor (for product performance or potential cost savings). In vehicles, some incentive is provided by fuel efficiency performance, and has also been strengthened by producer targets for average CO_2 emissions. For almost all other products, performance is not linked to steel, and steel cost is a small part of total machinery sale value. Again, there may be incentives to over-specify.

Even where there might be incentives and gains for change, it can be that some of these professionals will resist innovations which they are not familiar with - and so are locked in to the knowledge set which they were first trained in, even if it is outdated. As those professionals who are more established their careers, and therefore more influential in the design process, may be the ones more locked-in, there is an additional barrier to diffusion of new practices.

Therefore, the reduction of steel requires, as a first step, the dissemination of knowledge among designers, architects and value chain managers. It then needs to go beyond that, to find ways to incentivise (or require) reductions in use of steel for most steel applications outside of vehicle design.

2.4.2 Issues related to the whole value chain.

The better design of products to use less steel also often represents a wide range of actions, some of which cannot take place without change in the value chain, for instance they rely on the actions of actors further down the supply chain than the producers of steel. In these areas, to achieve innovation, a very wide range of design-related professionals need to work in vertical corporation with their suppliers.

However, with such a wide range of actors, there may be co-ordination barriers, which prevent any individual purchaser, or designer, from projecting the scale of demand which would be needed to stimulate innovation in their steel component suppliers. Thompson (2011) reports a lack of awareness about the usefulness of high-strength steel among the many fragmented buyers. This may imply a need for top-down intervention to promote the knowledge transfer across a wider set of end-users, for example that Government standards could play an important role in mandating this use of high-strength steel in different applications to ensure that this profitable opportunity is captured.

The nature of barriers to reducing steel use depends greatly on the product. The relationships along the value chain differ greatly between automobile parts and construction wire, for instance. (The auto-supply chain is described in more detail below).

In all cases, it appears that there is unlikely to be a problem with the supply of suitable steel, in a form to meet customer demand.

The steel value chain includes a small number of large producers of steel who create the smallest number of intermediary products) possible (e.g. sheet or rod steel) to avoid the need for those later on in the value chains to re-melt the steel. These steel products are sold-on as commodities to a large number of value chains, which further process and fabricate the steel and use them in a very wide range of applications and products. To produce this range of commodity steel products, there is an efficiency incentive for steel producers to achieve the level of vertical integration necessary, on large integrated sites. This small number of producers might lead to market dominance

However, there is significant over-capacity in the EU steel sector, and as commodity producers sell onto competitive markets, competition is tough, and margins are low. The level of market power of steel producers is typically limited to that provided by understanding and anticipating the needs of the end-users of steel and making changes to these products. The steel makers are price-takers and appear responsive to customer demand. The same seems likely to be true of commodity product makers (metal formers). So, on the supply side, there appears to be little economic resistance to innovation.

As the products using steel become more complicated, component makers may start to have slightly more influence over the market. However, this is not the case in the vehicle sector. The vehicle sector is characterised by a few, very large vehicle assemblers, who have very large market power over their suppliers (many of whom may have once been part of the vehicle maker, but whom have been divested).

In summary, there should be few problems on the supply side with demand-led reduction of the use of steel, although there may be political resistance to policy change to stimulate demand, as explained in the next section. [183].

[183] Including manganese and small quantities of copper, nickel, niobium, nitrogen, vanadium, chromium, molybdenum, titanium, calcium, rare earth elements, or zirconium

2.5 Winners & losers of optimal use of steel in in value chains

Figure 17: Assessment of possible winners & losers from optimal use of steel in product value chains

<table>
<tr><th></th><th colspan="2">Metals sectors</th><th colspan="3">Supply chain management</th><th></th></tr>
<tr><th></th><th>Alloy metal producers</th><th>Iron & steel</th><th>Supply chain contractors</th><th>Manufacturers/builders</th><th>Architects & designers</th><th>Consumers</th></tr>
<tr><td>The better design of products</td><td>-</td><td>Reduced sales</td><td colspan="2" rowspan="2">Possible value capture for 1st movers</td><td rowspan="2">Possible resistance to change</td><td rowspan="2">Cheaper & more efficient products</td></tr>
<tr><td>The greater use of high strength steel</td><td>Potential for value capture</td><td>Potential for value capture</td></tr>
</table>

Key:

Winner or not a loser
Possible or slight loser
Loser

The assessment of possible winners & losers from optimal use of steel as shown in Figure 17 suggest that there is potential for most actors with various supply chains to capture value from the optimal use of steel. The allocation of value will vary depending on who initiates the innovation. The two potential losers are iron & steel producers, in the case of better design of products which use less steel, and possibly some of the more established architects & designers and other professionals who oversee the product design and supply chains.

There may also be an opportunity for steel producers to further promote its use in the hope of capturing of some of the end-user benefits. Thompson (2011) reports the possibility that the wider use of high-strength steel could lead to resource constraints for materials such as manganese which are required for its production. It is therefore possible that producers of these materials will also capture some of the end-user benefits without initiating change.

In terms of power and influence, it is this later group who represent the greatest potential to resist change as the iron & steel sector are commodity producers and therefore price takers. Ultimately though, it is the manufacturers and builders who represent the capital investors and are therefore the actors best placed to ensure that innovation occurs on behalf of consumers. It is therefore in the interest of manufacturers and builders to ensure that architects & designers pursue innovation. In doing so, the first movers will capture some of the value whilst their competitors catch up. For markets where there are a sufficient number of providers to ensure competition, these innovations will in time become the norm. It will then likely be the consumer who eventually captures the full value.

The possible exception to this are the producers of the other metals required to produce high-strength steel who may maintain some level of value capture over time. The most likely of these is manganese, which represents about 2% of high-strength steel.

3 Food waste

3.1 Introduction

The purpose of this case study is to develop an understanding of the:

1. circular economy opportunities within the food supply chain;
2. structure of the food supply chain including the points of power and the contractual practices in place;
3. winners & losers within this system should transition or intervention occur.

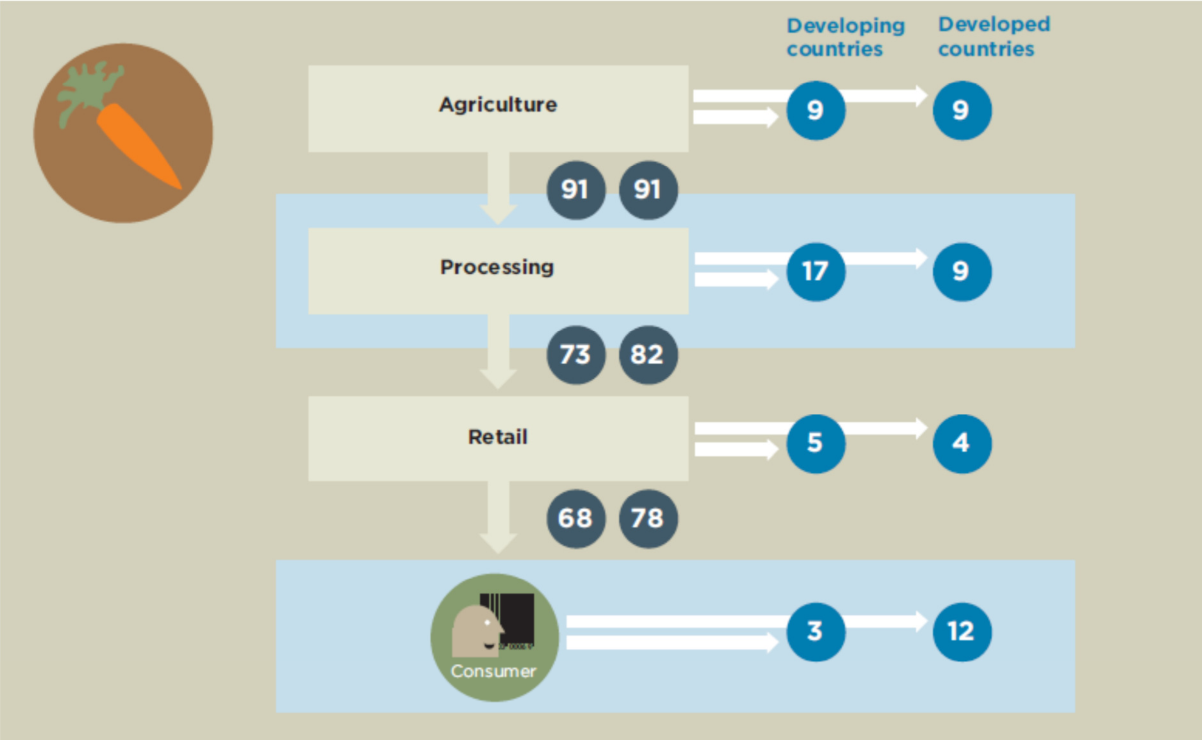
This case study adopts the food waste hierarchy as a guidance on priority cascading loops. This hierarchy includes:

1. Prevention of food waste;
2. Use in food banks;
3. Processing for food applications;
4. Use as animal feed;
5. Use as an industrial resource;
6. Anaerobic Digestion (AD);
7. Composting of wastes
8. Use as a renewable source of energy;
9. Incineration
10. Landfill.

3.2 The challenge of food waste

A notable proportion of the food produced for consumption ends up as food waste. In the EU27 around 90 million tonnes of food waste (excluding agricultural food waste and fish discards) is generated annually, corresponding to approximately 179 kg per person a year (European Commission, 2010). Food waste is generated throughout the food value chain, from agricultural production to household consumption. Globally about a third of the food for human consumption is wasted**Invalid source specified.Invalid source specified.**. This is confirmed by the work done by the Ellen MacArthur foundation (Vol 2) which found that 34% of food is wasted in developed and developing countries, the greatest source of waste being processing in developing countries and consumers in developed countries (see Figure 18). In the EU27, 42% of the food waste is generated in the household sector, 39% in the manufacturing sector, 14% in the food service/catering sector and 5% in wholesale/retail (European Commission, 2010). Within this, evidence suggests that up to 60% of the food waste is avoidable i.e. could have been consumed as food **Invalid source specified.Invalid source specified.**.

Figure 18: Sources of food waste as a percentage of total production



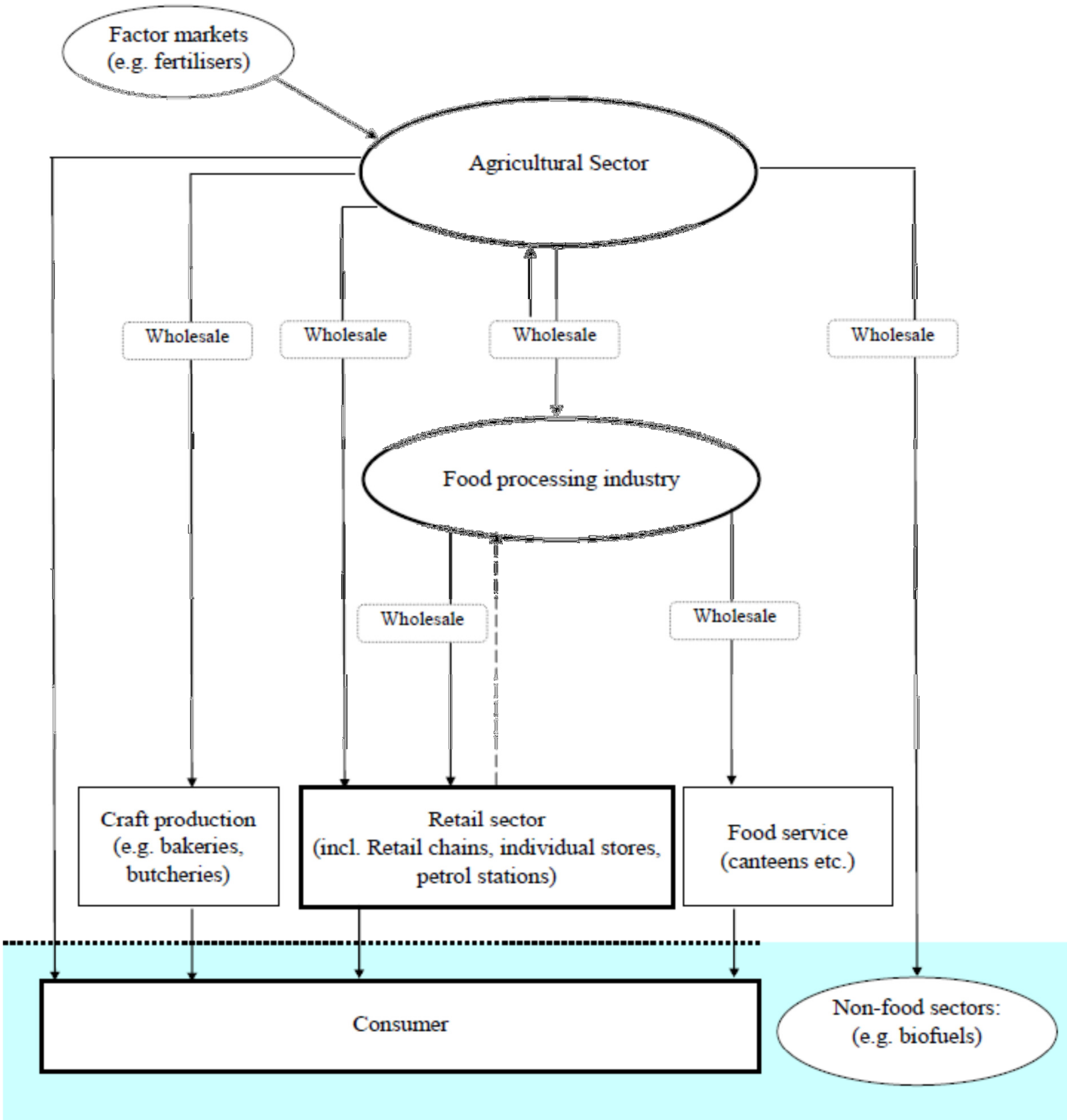
Source: Towards the Circular Economy: Opportunities for the consumer goods sector, Ellen MacArthur Foundation Vol 2

3.3 Structure of the food supply chain

The classic understanding of the structure of the food value chain as shown in Figure 19 involves outputs from the agricultural sector going via wholesalers to food processors, where it either goes direct to retailers and then consumers, or via further wholesalers before being sold to consumers via either retailers or food service companies. Alternative routes include wholesalers selling direct to small scale craft producers (such as bakers or butcheries) who sell direct to the consumer, as well as agricultural production which is sold directly to consumer (possibly via wholesalers) for them to process their own food.

This basic structure fails to account for the level of power and influence that different players exert within this system.

Figure 19: The basic structure of the food supply sector



Source: EC 2009

3.3.1 Consolidation in the food sector

The food supply chain is composed of a wide diversity of products and companies which operate in different markets and sell a variety of food products. Bukeviciute et. al (2009) highlight the impact of increasing consolidation within some parts of the food sector. [184] The paper explores how the degree of market power held by the firms along the chain varies by product category,

[184] Bukeviciute, L. Dierx, A. Ilzkovi, F (2009) European Commission Occasional Papers 47. The functioning of the food supply chain and its effect on food prices in the European Union. Retrieved from: http://ec.europa.eu/economy_finance/publications/publication15234_en.pdf

depending on the relevant markets in which these firms operate. This has an impact on the contractual relationships between the main players along the chain.

Whilst the EU food supply chain is relatively fragmented between Member States, some parts of the food processing industry, and the food retail sector in particular exhibit a relatively high degree of concentration.

One concentration of power has arisen via the growth of supermarkets, including the growth of trans-national retailers (like Tesco (whom operate in 12 countries globally), Walmart (27 countries) or Carrefour (24 countries). In most Member States the five largest retailer chains account for over 50% of the retail food market. Concentration levels are higher in the old Member States. A process of consolidation in the food retail sector is on-going across the European territory, but the consolidation movement is particularly strong in the new Member States.

Supermarkets have significant control over food processors, with very large shares of food sold being 'own label' products. Their share of the market has been increasing slightly in recent years. But another concentration of power in the food processing sectors comes from the concentration of production and marketing of products. Kantar Worldpanel data for the UK (2013), shows branded goods sales (think Coke, or Mars) account for around 46 to 48 % of total food and drink sales.

The concentration levels vary strongly across food categories and by extension food sub-industries. At the extreme end, for sectors such as biscuits and confectionery, the market share of top four producers is greater than 60%. In general, the firms that are active in these most concentrated food categories operate at global level and typically offer internationally branded products. Food products that are less differentiated such as bread, meat or flour are typically produced by food sub-industries that are less concentrated, including craft production (e.g. bakeries, butcheries). The result of this is that the incidence of private label and no-label products is more widespread in these less concentrated sub-industries.

There are further concentrations of power in particular sectors, in production, or wholesale, with local or global companies controlling flows of products, in agricultural commodities (e.g. seeds and oils), like Cargill, or in particular fruit - like the banana market, where 4 big players hold over a third of the market, and Chiquita and Ffyfes are looking to merge, to rival Dole and Fresh Del Monte. These concentrations of power have had an impact on the balance of bargaining power between the large buyers and the food producers and processors that they engage. This in turn shaped the contractual practices and arrangements made between large retailers and their producers and food processors. For example, there is general agreement within the literature that it is the retail sector that has a high level of control over the food sector generally and over their producers in particular. The practices and contractual arrangements of retailers has the potential for contracts to create waste.

Table 5- Examples of practices used within the food supply chain

Practice	Description
Purchasing agreements	Agreements concluded by competing buyers for the purpose of jointly buying certain inputs.
Resale price maintenance	Restriction of the buyer's ability to determine the sale price for end consumers.
Single branding	Obligation or incentive scheme which makes the buyer purchase practically all of his requirements on a particular market from only one supplier, for a certain duration.
Private label products	Products made by third parties upstream in the supply chain and sold under retailers' brand.
Tying	Purchase of a product (tying product) made conditional on purchase of other product (tied product).
Exclusive supply agreements	Direct or indirect obligation causing a supplier to sell a good only to one buyer.
Certification schemes	Requirement to comply with a number of conditions set by individual buyers.

The size and number of "buying alliances" in the food sector have grown considerably throughout the EU. These purchasing agreements are often concluded by small and medium-sized retailers and wholesalers to achieve volumes and discounts similar to their bigger competitors. These agreements between SMEs are therefore normally pro-competitive since even if a moderate degree of market power is created, this is likely to be outweighed by efficiency gains resulting from economies of scale (EC, 2009). The involvement of larger buyers in such alliances has led to increasing concerns expressed by food producers.

3.4 Detailed opportunities for greater circularity

Investments of energy and other valuable inputs are made throughout the length of the supply chain. Therefore, in terms of cost saving, reducing food waste at the latter stages of the supply chain can create greater financial savings than earlier up the supply chain. McKinsey (2011) estimates that three times the energy is saved if food waste is reduced at the latter stages of the supply chain, than if it is reduced within the production stage[185]. However, in terms of opportunities for circular economy, actions higher up the food waste hierarchy that capture higher value cascade loops tend to lay higher up the food value chain as once the food forms a

[185] McKinsey Global Institute (2011) Setting priorities for resource productivity. Retrieved from: http://www.mckinsey.com/assets/dotcom/HomeFeatures/Resource_Revolution/pdf/McKinsey_Resource_productivity.pdf

mixed waste stream within the household, it becomes more problematic to re-use it as a source of food or feed for hygiene and animal safety reasons. Therefore, although the greatest source of food waste with the greatest costs saving lays with the consumer, circular economy attention and intervention is also justified before the point of sale.

3.4.1 Retailer initiated circular economy actions

The literature broadly agrees that large retailers have a high level of control over the food sector generally and over producers in particular. Retail decisions can lead to wastage at producer level, due to a range of interlinked factors including: contractual requirements; product standards; and poor demand forecasting. Through this, they are in a position to influence the behaviour of producers, manufacturers and consumers.

The main source of preventable waste in retailing is perishable or fresh produce. Actions in this area therefore focus on stocking the precise quantities demanded and maximising shelf life. Both solutions typically require large retailers to initiate optimisation of the supply chain back to the manufacturer and growers. The food supply chain has the following circular economy opportunities for optimisation:

- Improved sales and shopping data to improve demand forecasts
- Active and intelligent packaging (e.g. packaging food in a protective atmosphere).
- Processing of retail food waste into animal feed.
- Active discounting (or donating) aimed at products approaching their best-by date (including diversion to discount retailers & food banks).
- Development of food redistribution programmes/food donation to reduce food waste. This could promote the resale/use of 'sub-standard' food products that are still safe for consumption.

Producers must work within the restrictions of legislative and cosmetic standards. In addition, retailers and manufacturers may impose additional cosmetic standards relating to weight, size and appearance. These can result in significant food waste pre-farm gate if crops are rejected because of their appearance or shape. Between 20–40% of these crops in UK farms are "never harvested" as they do not comply with the strict retail specifications. The House of Lords reported on a recent UK public opinion poll, which found that more than 80% of British shoppers would be willing to buy fruit and vegetables which are not perfect in shape or colour. Cultural differences across Member States may apply in terms of attitude towards fruit and vegetables and indeed Tesco sells a higher amount of "supplier seconds" in its central European stores. It therefore seems that consumers' preference for unified shaped fruit and vegetables might be tackled with price discrimination, and therefore the:

- Greater promotion of 'value ranges', either as part of existing ranges, or diversion to lower value consumers via alternative retailers.

In addition, there are a number of measures being developed within the DYNAMIX project[186] which would require actions among large retailers, most likely as a MS level.

[186] See http://dynamix-project.eu/homepage

Table 6 - Measures which require action among large retailers

Action	Aim	Key actors involved/impacted and role
1. Sectorial agreement with large food retailers to commit to eliminate most wasteful sales promotional practices.	To reduce overconsumption by decreasing unnecessary bulk purchasing of perishable items (e.g. buy 1, get 1 free, etc.)	– Retailers: participate in cross sector voluntary agreements to phase-out sales promotions for certain perishable items.

3.4.2 Policy enabled contractual reforms

Contractual arrangements of large retailers in particular have the potential to reduce food waste. Under some exclusive contractual arrangements between large retailers and their growers, producers may need to overplant to insure delivery of contracted volume. Furthermore, under such arrangements, if an order is cancelled, it is the farmer who is left with the unwanted production with few options for alternative markets.

The following opportunities are available to reform contractual arrangements between large retailers and their producers:

- Long-term contracts between retailers and producers could be encouraged, as they establish a more frequent or better understood ordering pattern.
- Longer notice periods for retailers to alter their volume orders.
- Whole-crop contracts where large retailers seek to negotiate contracts based on taking the entire crop.

Whole-crop contracts

The rationale being that it is the large retailers with their vertical reach of supply chains who are better placed to make best use of variations in volumes and quality. As the contractor of multiple suppliers, large retailers are able to manage the risk of variations in production in any one farm due to local conditions. Beyond this, as the centre of multiple supply chains, large retailers have more options to direct production into various uses. To illustrate with the examples of carrots, once the highest graded carrots have been sold whole, the next level of quality down carrots might be chopped into batons and used as prepared vegetables. Finally, the leftovers could be used within their own brand processing facilities to make pre-prepared foods such as soups, purées or ready meals. A UK case study suggested that adopting this method for potatoes improved crop use by over 20%.

Source: House of Lords 2014

3.4.3 Policy initiated actions aimed at consumers and SME caterers

The DYNAMIX project is also developing a number of measures aimed at consumers which are intended to be initiated by policy. The predominance of SMEs within the food service and hospitality sector presents distinct challenges to those faced by the retail sector. While the sector includes large multinational restaurant and catering companies, it is composed largely of SMEs such as independent restaurants and bars. Many of those measures aimed at consumers are also effective at dealing with food waste in this sector.

Table 7 – Actions that can be initiated by policies aimed at consumers and SME caterers

Action	Aim	Key actors involved/impacted and role
1. Develop public food waste campaigns such as the UK strategy 'Love Food, Hate Waste'.	To educate consumers on the negative health and environmental impacts of unsustainable food consumption. To promote profound changes in the way food is marketed, consumed and processed.	– Households: participate in the campaign by following recommendations and guidance – Authorities: promote the campaign and set the example for the public by also participating in the campaign
2. Review of eat-by labelling to ensure and implement a simpler system	To improve Consumer comprehension of food information to reduce food waste.	– Governments: implement policies or provide guidance regarding what dates manufacturers and retailers should print on their packaging. – Producers: removing unnecessary or confusing dates from packages and by changing how dates are displayed – Retailers: Ensure that accurate eat-by labelling is displayed on products.
3. Levy tax on all retail food unaccounted for in sales or used as feed-stock	To encourage retailers to reduce unnecessary food waste	– Retailers: pay the additional costs (tax levy) on food disposed of that is not accounted for in sales or accounted for in its wastes sent for anaerobic digestion or feed
4. Provision of segregated door-step collection of food waste and treatment in anaerobic digestion.	- To capture household food waste and circulate the material back into the economy. - To increase awareness among consumers of volume of their food waste.	– Municipalities to provide regular segregated door-step collection of food waste and treatment in anaerobic digestion
5. Landfill tax increase; charging for food waste disposal on a weight basis	To encourage households to reduce unnecessary food waste	– Local communities: to pay taxes based on the additional food waste generated by households

3.5 Winners & losers

	Potential winning actors	Potential losing actors	Influence of losers over change
Improved sales and shopping data	Retailers & consumers	-	-
Active and intelligent packaging		Some existing packaging manufacturers and processors	Limited
Active discounting or donating	Low income consumers	Retailers if scheme fails to distinguish recipients from high value consumers	Central
Development of food redistribution programmes			
Greater promotion of 'value ranges'			
Sectorial agreement aimed at wasteful sales promotional practices.	Consumers who struggle to anticipate their consumption	Retailers who compete on promotions	
Long-term contracts between large retailers and producers	Those producers who seek income security	Retailers who are contracting in size	
Longer notice periods for retailers to alter their volume orders	Producers	Retailers who have developed less vertical integration in their supply chains	
Whole-crop contracts for large retailers	Smaller producers		
Develop public food waste campaigns such as the UK strategy 'Love Food, Hate Waste'	-	To some degree food supply due to reduced sales	Low
Review of eat-by labelling	Consumers		Moderate
Levy tax on all retail food unaccounted for in sales or used as feed-stock	Animal feed renderers & anaerobic digestion owners	Those retailers more reliant on pre-packaged perishable foods and unable to innovate into biodegradable packaging	
Provision of segregated door-step collection of food waste	-		Low
Landfill tax increase on biodegradable content	-		Low

Analysis of the winners and losers from the various food waste actions suggest that:

- The main source of preventable waste directly preventable by the retail sector is perishable or fresh produce. Actions in this area therefore focus on stocking the precise quantities demanded and maximising shelf life, and then ensuring unwanted produce is either donated or sold as discounted products. The key issues here are that large retailers will want to ensure that donating food does not lead to health liabilities or that discounted sales do not impact on sales among their higher value consumers.

- Long-term contracts, whole contract contracts and longer notice periods within contracts are the opportunities available to reform contractual arrangements between large retailers and their producers. There is a rational for some of the larger large retailers to lead this reform: their vertical reach and size of their supply chains means that they are best placed to reduce overall system waste my managing variations in volumes and quality. However, this kind of reform will not suit all retailer's models.
- There are a range of actions as being developed by the DYNAMIX[187] project that can be initiated directly by policy. They include: public campaigns, review of eat-by labelling, levy tax on all retail food unaccounted for in sales or used as feed-stock, improved collection of food waste and increased landfill tax. For most of these, it would be the consumers and, tax payers and not retailers who are positioned to both influence and win or lose from the actions.

[187] http://dynamix-project.eu/

4 Plastics & the circular economy

Introduction

The purpose of this case study is to develop an understanding of the:

1. circular economy opportunities with the use of plastics;
2. structure of the relevant parts of the plastics supply chains, including the points of power;
3. winners & losers within this system should transition or intervention occur.

Plastics and the circular economy

Plastics have a very wide range of applications. They go to insulate a building's interior and exterior, can transfer air, water and sewage efficiently, enable ventilation and pre-heating of fresh air, and are essential to energy-saving household appliances. They are easy to install, versatile, cost-effective, long-lasting, easy to maintain and safe. There are a number of factors in the way that plastics are used within the economy which present a particular context for this case study:

1. Plastics offer a light-weight and de-materialised material option. Around half of all Europe's goods are now packaged in plastics, and yet plastics account for only 20% of packaging by weight. Furthermore, the increasing use of plastics in automobiles represents a major part of making vehicles lighter, and therefore more fuel efficient.
2. Most plastics are produced from non-renewables sources and if not properly managed at the end-of-life, can pollute the world oceans with plastic debris, which is emerging as a significant global concern[188].
3. The innovative use of plastics can sometimes lead to other material savings not possible in other materials. So for example, innovations in food packaging can increase the shelf life of foods and therefore reduce food wastes.
4. The range of different plastic resins and innovations in how they are put together means that in many cases, even when plastics are recovered, they end up being cascaded toward lower value applications or disposed of.

These issues within the existing system present a trade-off between the advantages of greater diversity of plastic products, the environmental concerns and the opportunity to create material loops. Whilst it might be desired to tackle all of these issues within a particular material loop, there may remain cases where the advantages of producing a plastic products which do not readily form a renewable or material loop, out-weight any benefits from repeated use.

To illustrate this range of these issues, this case study focuses on the winners and losses in relation to:

1. The greater use of plastics in the automobiles to achieve further weight reductions and therefore fuel further reduced requirements.

188 http://ec.europa.eu/environment/waste/plastic_waste.htm

2. The greater use of biodegradable bio-plastics in food packaging applications.

The structure of the plastics sectors

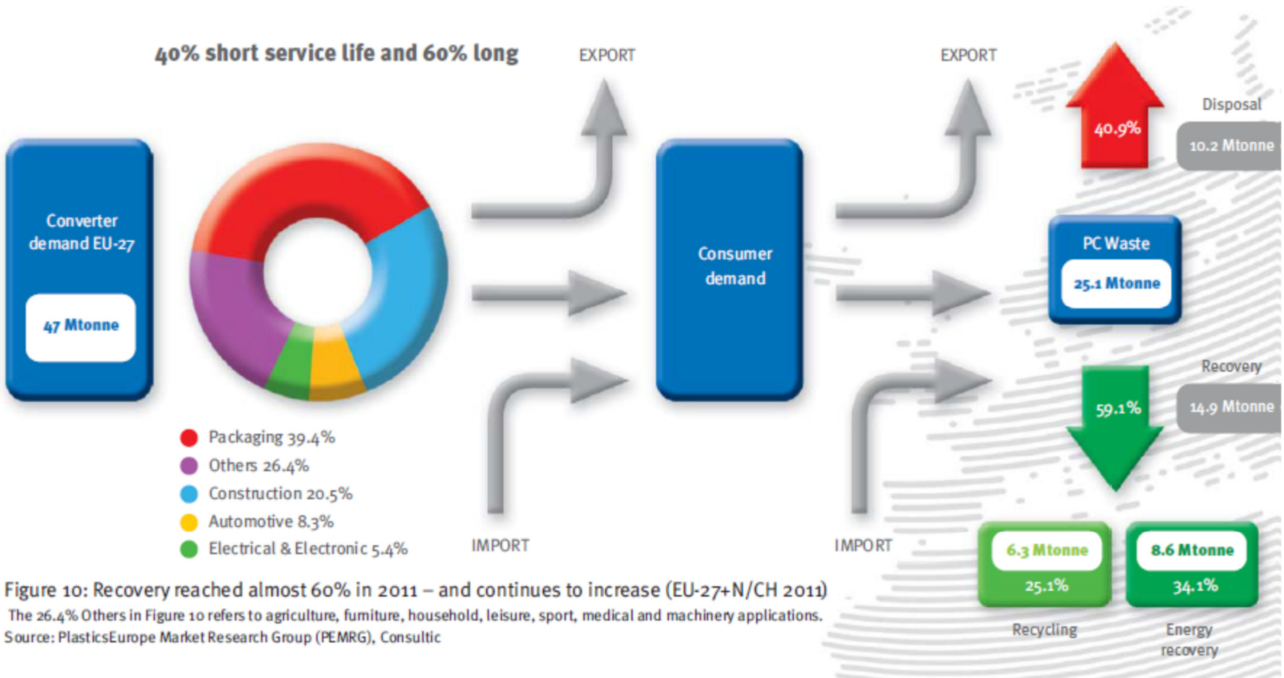
Plastics converters (or Processors) are the heart of the plastics industry. They manufacture an extremely wide range of semi-finished and finished products for industrial and consumer markets, including the automotive electrical and electronic, packaging, construction and healthcare industries. Plastics converters buy in raw material in granular or powder form, subject it to a process involving pressure, heat and/or chemical processing and design manufactured products. They often undertake additional finishing operations such as printing and assembly work to add further value to their activities.

The European level association, the EuPC totals about 51 European Plastics Converting national and European industry associations. EuPC represents close to 50,000 companies, producing over 45 million tonnes of plastic products every year. The sector employs more than 1.6 million people in about 50,000 companies (mainly SMEs in the converting sector) to create a turnover in excess of €280 billion per year.

Material flows of plastic in the EU

Figure 20 shows that production of plastics in Europe (EU27 + Norway and Switzerland) was 47Mtonnes in 2011. After plastics were imported and exported as products and wastes, 25.1 tonnes arose as post-consumer waste requiring management. Of this, 14.9Mtonnes or 59.1% was recovered (6.3 recycled & 8.6Mtonnes through energy recovery) and 10.2Mtonnes or 40.9% was disposed of to landfill.

Figure 20 – Material flow of plastics in EU27 +2 in 2011



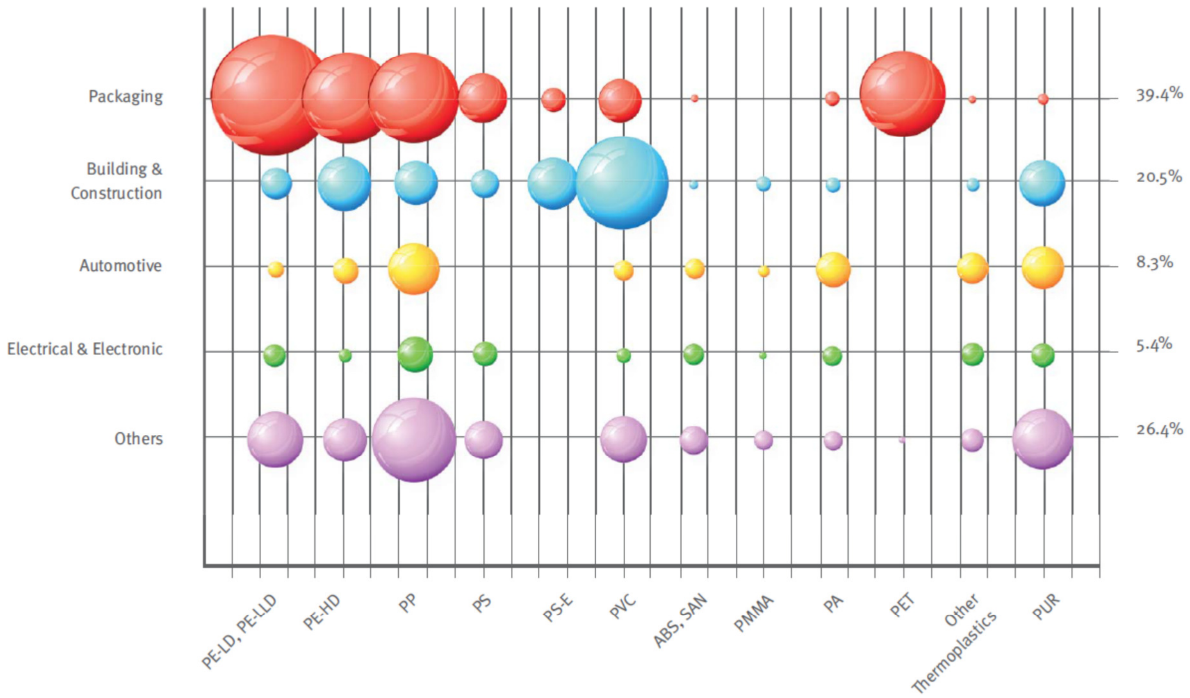
Source: Plastics Europe 2012

Approximately 4% of the fossil fuels that enter the economy is used by convertors for the production of plastics (Arcadis 2010, p. 193). There are different types of plastics with a variety of grades to help deliver specific properties for each application. The "big six" plastic types that stand out in terms of their market share are in Europe include (with % demand in Europe):

1. polyethylene – including low density (PE-LD), linear low density (PE-LLD) and high density (PE-HD) – 29%
2. polypropylene (PP) – 19%
3. polyvinyl chloride (PVC) – 11%
4. polystyrene solid (PS), expandable (PS-E) – 7.5%
5. polyethylene terephthalate (PET) – 6.5%
6. polyurethane (PUR) – 7%

Together these account for around 80% of the overall plastics demand in Europe.

Figure 21 - Demand for plastic by sector and resin type - 2011

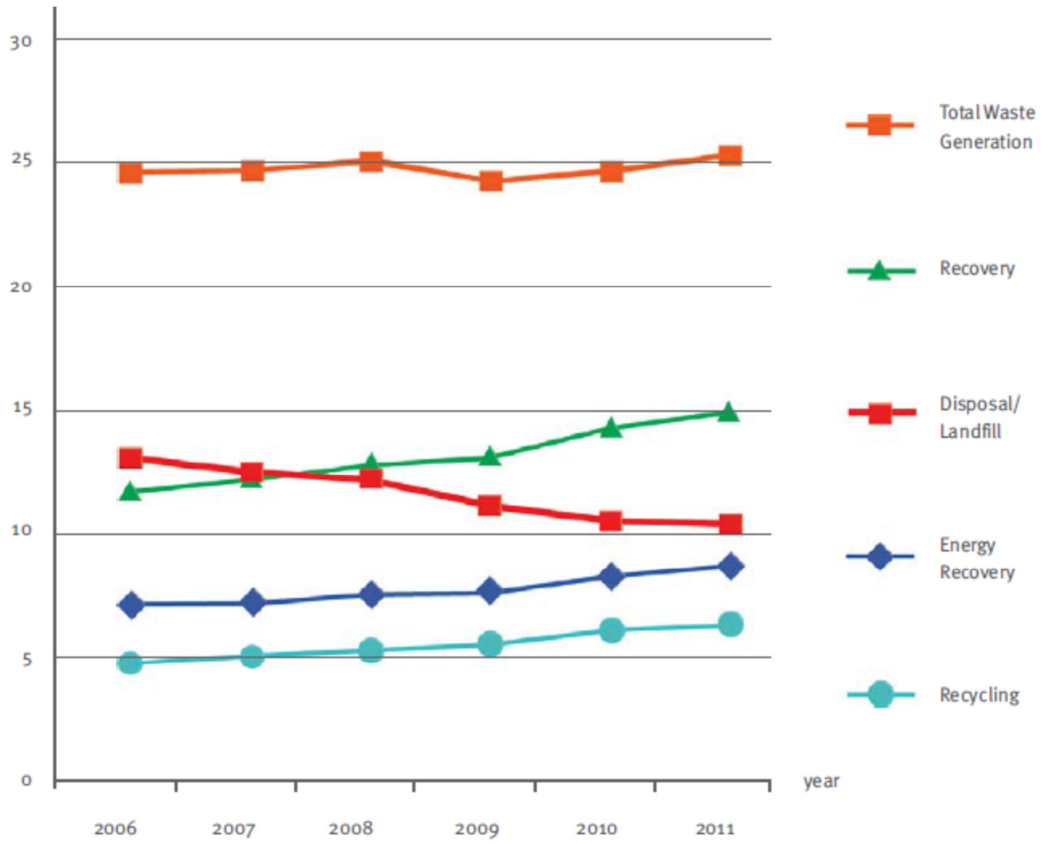


Source: Plastics Europe 2012

Figure 21 shows that the largest user of plastics is the packaging sector at 39.4%. The second largest specific sectoral use, construction uses 20.5% of total plastics. Figure 21 highlights how the different resin types are sued within the different sectors, and therefore the potential challenge in matching material for cascading opportunities. To illustrate, the construction sector uses a significant amount of PVC which could not be met by the other sectors and may not be recovered by the construction sector as much of it will remain embedded over the longer term.

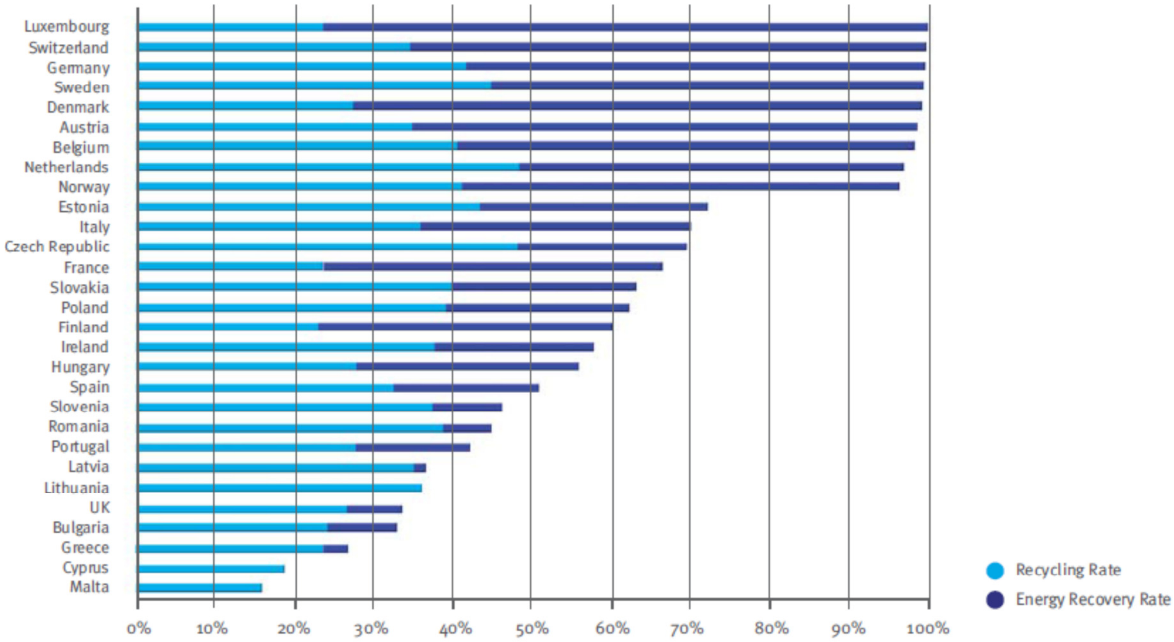
Figure 22 shows that, whilst the total amount of arising's of plastic wastes stayed broadly stable at about 25Mtonnes from 2006-2001, the rate of recovery increased from about 12Mtonnes to 15Mtonnes.

Figure 22 - Total plastics waste recycling and recovery 2006 – 2011



Source: Plastics Europe 2012

Figure 23 - Total Packaging Recovery Rate by Country 2011



Source: Plastics Europe 2012

Recycling and recovery rates for plastics packaging is higher, 66% compared to 59% for all plastics as shown in Figure 20. This reflects the focused efforts over a longer period to develop recycling and recovery options particularly in Norway, the Netherlands, Belgium, Austria, Denmark, Sweden, Germany, Switzerland and Luxembourg where total recovery rates are approaching 100%. In all of these countries, recycling makes up more than half of this rate of recovery.

The greater use of plastics in the automobile sector

Plastics is an increasingly used material to meet the demands of the modern automobile sector. While motorists want cars with greater comfort, reliability, fuel savings, style and lower prices, society demands lower pollution levels and increased recovery at end of life. At the centre of this challenge is weight reduction and the innovative use of plastics. The result being that today's cars would be an estimated 200-300 kg heavier without such a widespread use of plastics and would use 0.5 litre per 100 km more fuel, which represents 750 litres savings for a car with a lifetime of 150,000 km[189].

[189] http://www.plasticsconverters.eu/organisation/division/automotive

Box 1: Uses of plastics in the automobile sector

Many types of polymers are used in more than 1,000 different parts of all shapes and sizes. Although up to 13 different polymers may be used in a single car model, just three "families" make up some 66 % of the total plastics used in a car: polypropylene (32 %), polyurethane (17 %) and PVC (16 %). Plastics are now used in exterior and interior components such as bumpers, doors, safety and windows, headlight and side-view mirror housing, trunk lids, hoods, grilles and wheel covers with the passenger compartment being dominated by plastics.

- Under-bonnet there has been a widespread adoption of large (1.5 to 2.5 kg) mouldings for air intake manifolds in glass fibre reinforced nylon. These are not only half the weight of their metal counterparts: they optimise the airflow to the engine, helping to make it more efficient, and also playing a valuable role in reducing noise levels. Looking forward, automobile engineers are working to optimise other systems: integrating injection and blow moulded parts, and harnessing plastics and elastomers.
- Plastics are also finding their way into the structural design of cars. Intensive development of thermoplastics has opened the way to production of individual bodywork panels by injection moulding, to meet the high temperature of the paint stoving ovens used by the automotive industry, and electrically-conductive grades, for electrostatic painting.
- The most complicated design problem the fuel tank system has been solved thanks to plastics. Another important area of development is in fuel systems. For more than a decade, all-plastics fuel tanks have been produced by blow-moulding in ultra-high molecular weight high density polyethylene. Originally, tanks were treated internally to reduce the permeability of polyethylene. But, to meet tightening emission standards, multi-layer tanks are blow moulded, incorporating a layer of a high barrier polymer, and tie-layers to bond it to the structural inner and outer layers. A sixth layer is usually added, to re-use the scrap produced in manufacturing. It is estimated that some 90 % of all new cars in Europe have these lightweight tanks.
- Reinforced thermosetting resins also have future potential. There is nearly fifty years of experience of the use of glass fibre-reinforced resins in production of bodywork in low-volume production sports cars. More recently, improvements have been made in the development of processes for moulding fibre-reinforced polyesters and polyure-thanes at viable mass-production levels, and there is an increasing number of exterior bodywork panels and bumper systems that are produced in volume in these thermosetting materials.

Source: Adapted from Plastics Europe 2012

The greater use of bio-plastics in food packaging

The term bio-plastics refers to either or both of these two broad categories:

1. Bio-based plastics that are derived from renewable resources; or
2. Biodegradable (compostable) plastics that meet standards for biodegradability and compostability.

Bio-based plastics can be either biodegradable or non-biodegradable. Similarly, biodegradable polymers can be petroleum-based. For the purposes of this case study, bio-plastics are assumed to be both bio-based and biodegradable.

The 2011 study by Bio Intelligence Services (Biois 2011) anticipated that EU bio-plastics consumption is estimated at around 0.1-0.2% of total EU plastics consumption and were 1.5 to 4 times more expensive than conventional plastic materials in 2006. It also reported that the market for biodegradable polymers were growing in 2009 in the range of 5-10% and Europe accounts for around half of global consumption, while North America and Asia (including Japan) account for around a quarter each. This difference may stem from Europe already having large-scale composting capacity which makes the use of this material more economically attractive than in the United States.

The main drivers for biodegradable polymers are landfill capacity, pressure from retailers, consumer demand, and legislation based on concern over fossil-fuel dependence and greenhouse gas emissions. However, the extent to which bio-plastics can address these issues is a matter of some debate as the environmental qualities of bio-plastics have not yet been documented comprehensively. Key considerations are the amount of non-renewable energy used in their manufacture and potential land-use implications. For bio-plastics producers, an important challenge is to widen the range of bio-plastics types and possible applications so that they become functionally equivalent to petro-plastics.

Bio-plastics can potentially be used for a wide range of applications and can offer new functional properties: for example, starch foams have better anti-static properties than conventional foams. However, bio-plastics cannot yet replace all types of petroleum-based plastics for all applications. In particular, packaging material can have stringent requirements such as gas permeability. It may therefore be that bio-plastics will not be able to replace all types of food packaging for such technical reasons (resistance, durability, etc.). The main future applications anticipated for bio-plastics are expected to be disposable plastic bags and packaging items and growth of the bio-plastics market is likely to be particularly strong in food packaging applications.

The environmental case for using bio-plastics

A number of potential benefits are claimed for bio-plastics.

1. The use of plastic products manufactured from renewable resources reduces the use of fossil fuels and decouples the products from high and volatile fossil-fuel prices, though the relationship is complicated by the fact that plastic products make use of by-products of the refining process.
2. Bio-plastics might improve manufacturing process efficiency.
3. Biodegradable bio-plastics are less persistent in the environment than non-degradable plastics.
4. Biodegradable bio-plastics can be composted, reducing the amount of waste sent to landfills.
5. The CO2 emissions released at the end of life of bio-based bio-plastics (through incineration, decomposition, etc.) are offset by the absorption of CO2 during plant growth.

However, existing LCA results differ significantly depending on the methods used, the system boundaries, the impacts considered and also their year. A few LCAs (15% of those reviewed in the Bio 2001 study) indicate that petro-plastics can have lower environmental impacts than bio-plastics, taking into account data on the actual number of recycling loops possible, the energy consumed during manufacturing and end-of-life disposal (methane generation in landfills). Behind this is that, as the recycling of most biodegradable plastics is currently not viable, this type of plastic is still disposed of.

Winners and losers in the greater use of bio-plastics in food packaging

The case study on food highlights that that large retailers have a high level of control over the food sector generally and over producers in particular. It is therefore them who are a central stakeholder in the greater use of bio-plastics in food packaging. There will be process advantages for them, as well as reputational to the degree that consumers demand the wider use of bio-plastics in food packaging. Overall, the greater use of bio-plastics in food packaging presents the following opportunities and challenges for the following sectors of the economy:

- In the retail sector, the use of biodegradable packaging, particularly in highly perishable products such as fresh fruit and vegetables, offers the opportunity of co-disposal of food wastes and packaging in compostable form without emptying its contents.
- Some consumers value the environmental benefits presented by the use of bio-plastics in food packaging. Consumers generally will benefit from the convenience of co-disposal of packaging and food wastes in compostable waste collection systems where these exist.
- The plastics and packaging sectors are faced with the requirement to innovate to produce both the bio-plastic material and integrate this into existing package producing processes. If demanded by consumers and retailers, those first to produce bio-plastic packaging stand to profit from their innovation. However, all in this part of the supply chain risk stranded capital and therefore may resist the introduction of bio-plastic packaging.
- In the food-waste composting sector, a complete transition towards degradable food packaging would improve the purity of the resulting composted output.
- In the recycled plastics industry, the increased use of bio-plastics in food packaging could potentially lead to the contamination of recycled plastics by bio-plastics, affecting the quality and physical integrity of the resulting material. Investment may be needed in sorting technology to deal with this challenge. For instance, bio-plastics can lower the quality of recycled material such as PET bottles if they are not properly removed during the separation stage. This risks reducing the value of recovered packaging material to municipality waste collection services.
- In the food and agricultural sector, there is concern that crops otherwise used for food, may be used instead for the production of bio-plastics, putting stress on food resources.

The winners and losers of the greater use of bio-plastics in food packaging has been assessed in Figure 24.

Figure 24 - The winners and losers of the greater use of bio-plastics in food packaging

	Supply chain		**Use phase**	**End-of-life phase**	
	Packaging sector	Retailers	Consumers	Waste managing municipalities	Users of recovered material
The greater use of bio-plastics in food packaging	Innovation required: First mover profit	Co-disposal of unused food products in compostable packaging & increased environmental credentials		Possible increased value of recovered food waste	Possible increased quality of food-waste compost
	Risk of stranded capital	Possible increased product prices		Possible reduced value of recovered plastics	Possible decrease quality of recovered plastics

Key:

Winner or not a loser
Possible or slight loser
Loser

The assessment in Figure 24 suggests that all of the key players are potentially both winners and losers. The players who are best positioned to introduce bio-plastic packaging, the retailers and consumers, are set to gain from co-disposal and therefore potentially cheaper and easier waste disposal costs. This needs to be weighed against the additional cost of bio-plastic in packaging and the retailer's ability to engage with the packaging supply chain and entice further innovation.

In the event that policy proposed the introduction of bio-plastics food packaging, other players would be in a position to influence the process. The quality of recycled plastic could be reduced and therefore the revenue that waste those municipalities who manage wastes will receive from the recovered plastics from households. This would need to be weighed against the possible improvement in value of recovered food waste from households where this was collected separately and it will be less contaminated by plastic wastes. There could therefore be those within the recycling sector and local municipalities who would seek to resist the greater introduction bio-plastic packaging.

Winners and losers in the greater use of plastics in automobiles

Analysis of the automobile sector from this case study and previous sections of this report suggests that:

- There is the incentive and regulatory requirements for manufactures to produce lighter more fuel-efficient vehicles.
- The innovative use of plastics offers further opportunities to achieve this including the development of processes for moulding fibre-reinforced polyesters and polyurethanes for number of exterior bodywork panels and bumper systems.
- It is the car manufacturers who possess the power to initiate change within the supply chain.

Figure 25 - The assessment of winners and losers in the greater use of plastics in automobiles

	Supply chain			Use phase	End-of-life phase
	Component suppliers	Teri-one suppliers	Automobile manufacturers	Consumers	Vehicle processors
The greater use of plastics in automobiles	Winners & losers but with little power to influence change.	Opportunity for value capture depending on who initiates innovation		More efficient automobiles	Fewer components to dismantle
		Risk of stranded capital		Possible caution to extensive & visible plastics	Reduced scrap material (i.e. steel)

Plastics (2012) reports that the development of plastics in automobiles is prompting engineers to take a more integrated systems approach. In addition, there is an emergence of "Tier One" suppliers within the automobile supply chain who are large, well-financed groups, operating globally, able to undertake the engineering, manufacture of whole modules, and deliver them to assembly lines 'Just-In-Time'. These suppliers therefore can begin to capture some of the power and therefore profit within the supply chain. In many cases, innovation will be initiated by automobile manufacturers. In others cases however, the increased power of tier-one suppliers may lead to innovation occurring at this level and passed to a number of manufacturers. Overall, it is likely that the supply chain will innovate in partnership and will distribute the any profit on a case-by-case basis.

The assessment shown in Figure 25 suggests that the interests of the key players in the automobile supply chain are incentivised to further innovate and further incorporation of plastics into automobiles. Some consumers may be cautious of the extensive and visible use of plastics in vehicles. However, this process is already very much a reality in modern automobiles and manufactures will need to continue to be conscious of how the product presented. Overall, the incentive and requirement for fuel savings will very likely ensure that further innovation will be implemented.

There are numerous opportunities to recover and reuse plastics at the end of life. However, its material characteristics, combined with its generally low material value means that plastics will continue to be designed for single or limited number of uses. Furthermore, the range of different resin and plastic types, which are not easily distinguished by the end-user, means that it is likely that much recovered plastics will be put into cascading use in the construction rather than automobile sector. Applications include insulation, flooring and fabrics.