Towards a Circular Products Initiative in the EU

Report of the

Leiden-Delft-Erasmus Centre for Sustainability

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About the Leiden-Delft-Erasmus Centre for Sustainability

The Centre for Sustainability focuses on the sustainable production, management and use of resources in an urbanizing society. It develops and provides research based knowledge, innovation and solutions on resource efficiency and circular economy.

Collaboration in the Centre for Sustainability leverages the complementary strengths of the three universities as knowledge centres in the fields of Science, Technology and Business. Through participating in joint projects in interdisciplinary research groups, specialists work together on shared research roadmaps and translate research based knowledge into solutions for resource efficiency. The objective of the Centre for Sustainability is to build a triple helix consortium in partnership with companies, governments and universities.

The Centre for Sustainability is a joint multidisciplinary centre of Leiden University, Delft University of Technology and Erasmus University Rotterdam in The Netherlands. It was founded as one of eight joint centres as part of the Strategic Alliance between the three universities.

1 Introduction

The circular economy provides huge opportunities for reducing the ecological footprint of products and for businesses (by reducing dependency on volatile virgin resource markets and creating post-consumer positive value for products). Amongst others by the work of the Ellen MacArthur foundation the concept of a Circular Economy has in recent years witnessed a revival in popular and policy attention, but is by itself not a new concept: many products are already recycled or refurbished; and policy efforts over the last decades, including a wide range of existing EU instruments have contributed to further closing of material loops. In the last years, particularly DG Environment has made much work of policies towards sustainable management of resources, products, and systems of production and consumption, as reflected by the recent EU Communication on a Circular Economy of Summer 2014. The challenge for the coming years is to move from down-cycling to adding value throughout the cycle, to stimulate designing products for their whole life cycle and to address those material and product types that remain hitherto largely linear. Eventually, the new Circular Economy, like the traditional circular economy, will be driven by the positive economic it creates; for the foreseeable future strong policy instruments will be necessary during the transition.

The Netherlands chairs the EU in 2016. It is desirable that the relevant Ministries in the Netherlands that want to undertake initiative under the Dutch Presidency, prepare relevant dossiers already in 2015. In view of the challenge above, the recent Communication from the Commission **'Closing the loop - An EU action plan for the Circular Economy' (COM(2015) 614 final)**, and given the long history and experience in the Netherlands in product policies, the Dutch Ministry of Infrastructure and Environment wants to see if during the Dutch Presidency further support for the EU's circular economy dossier can be provided, by investigating the potential for enhancing, streamlining and optimizing the current set of instruments for environmental product policy at European level, summarized under the header 'a Circular Products Initiative (CPI)'. The Ministry of Infrastructure of Environment assigned experts from the Centre for Sustainability, a collaborative research centre of Leiden University, TU Delft and Erasmus University to conduct this work.

Our working hypothesis is that a mix of policy instruments is required that collectively transforms linear chains into profitable circular chains. Instruments addressing one link of the chain affect other chains both positively and negatively. How chains react to policy mixes is crucially dependent on the structure of the chain and underlying industries. Understanding these structures is thus crucial for developing effective, integral policy.

Our research approach will be to analyse and give:

- the structure of chains and industries and the nature of instruments (by a typology) and how synergies of instruments can be realized given these typologies (Chapter 2)
- current EU-instruments aimed at closing material flows (Chapter 3)
- case studies analysing the effects on product chains that these current instruments have, depending on the structure of the chain (Chapter 4).
- needs and opportunities for adapting the current policy mix, to an 'Circular products initiative' mix by: (1) adapting existing instruments for more effect on the whole chain; (2) focusing instruments for blind spots in the chain and (3) developing systemic instruments that address the need for chains and industries to change at a systems level (Chapter 5).
- Conclusions (Chapter 6)

2 Theoretical context: understanding policy mixes for circular product chains

2.1 Introduction

One of the key premises of this study is that an improved alignment of policy instruments aimed at products will give better and more efficient results, and realise the goal of a circular economy easier and with less costs. This inevitably implies that the analysis of effectiveness of policy instruments must be based on a systemic view, rather based on effectiveness assessments of single instruments focused at specific points in the life cycle. In this chapter we want to review of scientific literature that has analysed how policy instruments can create most synergies. We then can analyse in Chapter 3 the current product policies at EU level against this backdrop, and make suggestions for optimization.

Literature that gives empirical proof that quantifies the effectiveness of individual policy instruments is already scarce. This is even more the case for studies looking at policy mixes. Sorrell[1] flatly declares: “[p]olicy interaction is neglected in the academic literature”. Some qualitative studies have been done since then, though, into the question under what conditions the use of combinations of instruments is more effective as single instruments. Examples include Bennear and Stavins[2], OECD[3], Fankhauser et al.[4], Ring and Schröter-Schlaack[5] and work of the IPCC[6] and the IEA[7]. Most of this work has been done in the area of climate change focusing on process emissions, but in the next sections we will analyse what lessons this literature provides for (circular) product policy.

We start this chapter with describing a conceptual framework for circular product chains, and discuss the importance of chain and industry structure (section 2.2.). Section 2.3 addresses which type of instruments exists to influence these chains, how they relate to markets and how steering on one link in the chain, will affect others. In section 2.4, on policy mixes, the interaction between instruments, the logical sequence of instruments over time and the implications for policy mixes for circular product chains will be discussed. We will end with a conclusion of key aspects in analysing and developing circular policy instrument mixes (2.6).

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[1] Sorrell, S (ed., 2001:30). Interaction in EU climate policy. SPRU, Brighton, UK, EU FP5 project number EVK2-CT-2000-0067

[2] Bennear, Lori Snyder and Robert N. Stavins (2007). Second-Best Theory And The Use Of Multiple Policy Instruments. Environmental and Resource Economics 37 (1) 111-129

[3] OECD (2007), Instrument Mixes for Environmental Policy. OECD, Paris, France

[4] Fankhauser, Samuel, Cameron Hepburn and Jisung Park (2011). Combining multiple climate policy instruments: how not to do it. Centre for Climate Change Economics and Policy Working Paper No. 48 / Grantham Research Institute on Climate Change and the Environment Working Paper No. 38, University of Leeds and London School of Economics, UK

[5] Ring, I., Schröter-Schlaack, C. (2011). Justifying and Assessing Policy Mixes for Biodiversity Conservation and Ecosystem Services Provision. Special Session on 'Instrument Mixes for Biodiversity Policies', ESEE 2011, Istanbul

[6] Gupta, S., D. A. Tirpak, N. Burger, J. Gupta, N. Höhne, A. I. Boncheva, G. M. Kanoan, C. Kolstad, J. A. Kruger, A. Michaelowa, S. Murase, J. Pershing, T. Saijo, A. Sari, 2007: Policies, Instruments and Co-operative Arrangements. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, US

[7] Hood (2011), Combining Policy Instruments for Least-Cost Climate Mitigation Strategies. International Energy Agency, Paris, France

2.2 Circular product chains

2.2.1 A conceptual framework

In an ideal circular product chain, materials (or whole products) are recycled and losses in each link of the chain are minimal. At least as important, products retain their economic value, so waste becomes a valuable resource. We have to accept that as long as there is economic growth and a built-up of economic stocks, full circularity is impossible: in such growth stages inevitably there will be a net transfer of materials from the natural system to the economic system. The size of this effect depends strongly on: 1) the product lifetime (compare the lifetime of a building to the lifetime of a plastic bottle), 2) growth in product consumption and 3) the extent to which higher levels of economic output can be achieved with lower levels of material (de-materialization) and energy input. The ideal circular product chain is pictured in Figure 2.1. Note that for simplicity we depict a single cycle, whereas product cycles can exchange material flows and products can be merged or combined (for example packaging around a food substance).

In a typical fully linear product chain, throughout the chain significant material losses occur. Any positive economic value to the product is after consumption completely lost, making the waste collection and incineration an economic burden for the producer, consumer or government (see Figure 2.2). In the real, present world, many product chains are in between linearity and circularity. Some recycling occurs, but losses throughout the cycle (especially in the waste phase) are considerable. Also, after consumption the product still has a negative value, which typically still requires regulation to enforce recycling (see Figure 2.3). Sometimes the costs of recycling, might even be higher than the costs of disposing.

2.2.2 Chain and underlying industries structure

These physical chains of material and product flows are embedded in an economic and social context. In our highly specialised economic system, supply chains can feature dozens or even hundreds of firms who process and combine materials and components. After consumption, the recycling (or disposal) chain can be complex as well, involving various waste-related industries and firms. In the circular economy the complexity of this ‘reverse logistic’ system can be expected to increase. A typical supply chain, and especially a linear one, will cut through various different industries and service sectors. The structure of such chains can be quite complicated, from literature, we can identify a number of key aspects in understanding differences between chains and their implications[8]:

Standardisation or diversity

Some industries, or more specific lines-of-business, produce one or a few products or materials in bulk. In these industries, the buyer has very little influence on the composition or the way the product was produced and the producer himself can also not easily introduce a sustainable product (or material) if it does not meet formal or informal standards. Typically these are also economies of scale, thus introducing a new alternative material or product is difficult. On the other hand, other industries produce for individual customers or orders, allowing customers to directly affect production (deep order penetration point). Other industries might produce to stock, but have a diverse portfolio of products, and can easily accommodate an explicit or latent demand by a group of buyers with a new or modified product or material

[8] Another important topic in product (supply) chain literature are timing issues, for example how quickly a change in demand can be translated to a change in supply of resources, this is less relevant for circular product policy.

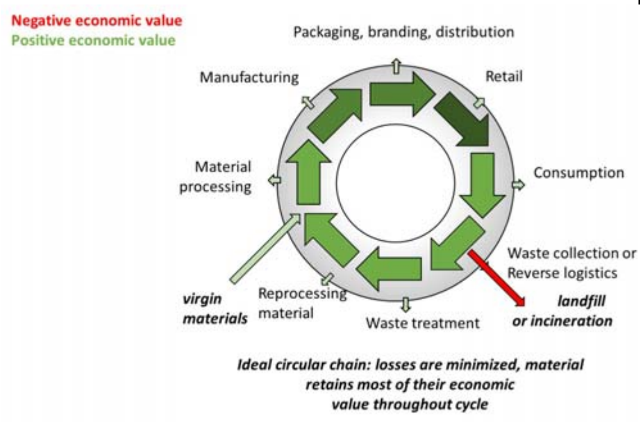
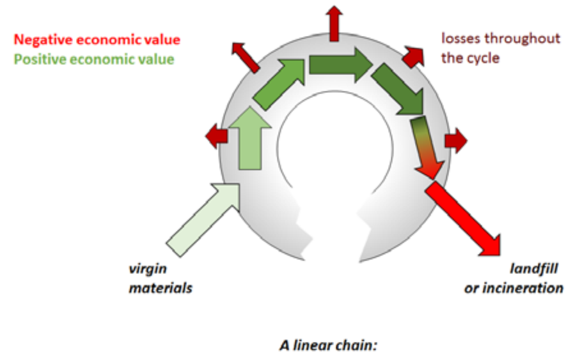
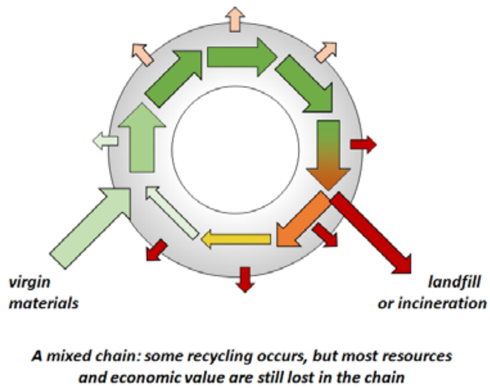
Figure 2.1: Fully circular product chain	Figure 2.2: Fully linear product chain
	

Figure 2.3: Typical mixed life product chain with some recycling



Technological flexibility and sunk investments

Various factors play a role in standardization and (amongst which safety concerns and regulation), but a major factor is the level of **technical flexibility** in the chain, and the **potential for incremental improvement**. If actors in the chain are rather flexible with regard to which technology to use, product chains lend themselves easily for incremental improvements that really lead to high environmental gains (e.g. relatively simple add-on measures like recovering scrap steel with magnets from waste flows for recycling), whereas in other cases a full overhaul of products is needed to ensure improvements (e.g. currently small quantities of rare earths used in electrical and electronic equipment can hardly be recovered due to their diffuse application, and a full redesign or 'designing out' of such materials is required to overcome this problem).

This inflexibility combined high capital costs leads to **sunk investments.** It is pretty obvious that a production chain depends on expensive infrastructure that is not yet written off, there will be a significant resistance to change. For instance, existing electricity production infrastructure – it takes years to gain back the investment in a power plant. More broadly though, one has to understand that such existing infrastructures extend to more intangible cost factors, such as existing supply chain and retail networks, financing systems, norms related to this, and expertise and craftsmanship that becomes all of a sudden useless when a shift to a fully novel product system is at stake.

Organisation, trust and power

Chains can be organized in various ways. Gereffi et al. (2005)[9] developed an overview of archetypical chain structures (see figure 2.9). Some chains (or links in a chain) are characterized by open markets in which buyers and sellers easily switch between trading partners. The other extreme are vertically integrated firms, which control the entire chain. For circular chains, we see the first examples of such vertically integrated approaches (e.g. manufacturing firms being directly involved in refurbishing and recycling or a waste company becoming a products manufacturer). In between these extremes are various models in which multiple firms enter into long term relationships. In some models, partnerships are equal, whilst others clearly show a dominant position of manufacturers or distributors/retailers in the chain.

From a pure neo-classical economic view, open markets with negligible transaction costs might be preferred. For sustainability and innovation, the situation is more complex. For example, 'choking points' or 'power nodes' can work out good or bad – bad if these power nodes clearly have an interest in the status quo (e.g. due to sunk costs relevant to them), good if they have flexibility to manoeuvre and then exercise their power to transform the chain. The latter happened for instance in the example of the coffee system, where roasters and retailers pushed through certification systems that now cover some 50% of sales in many countries in Europe. For government a few, powerful actors with control over the chain might be a formidable opponent in terms of resistance and lobbying, but it also allows to directly engage with these actors and if for example voluntary agreements can be made, the risk of new entrants or smaller producers free-riding is less. More factors than economic and legal positions play a role in how a chain functions. Regardless of the economic organisation, even (or especially) long term equal relationships might be characterised by constant negotiation and mistrust, or partners might corporate and trust each other for the common good.

One crucial factor if concentrated power in a chain is an enabler or barrier is how radical the required sustainability change is. If the required change is incremental, costs are minimal and do not fundamentally affect the way goods are produced and business is being done, well-organised incumbent actors with vested interests can be an enabler to realise change without the need of repressive instruments. If the required change is fundamental, vested interests tend to be more of a source of resistance. The obvious reason are the sunk investments and risk of losing the current dominant position in a fundamentally transformed industry. Reasons are also less rational: current paradigms about what a product and the market constitutes, and how production and business is being handled can blind incumbents for seeing long term opportunities (or necessity to change).

Large scale changes in industry are often missed by large incumbents. Examples are the emergence of internet (leaving the conventional entertainment and IT industry behind), or on a smaller scale the move from analog to digital photography (with many firms making a late or too late transition). Or more historical: new energy sources are seldom exploited by the existing energy industry.

Individual and collective 'Prosumers'

The above assumes a traditional value chain in which consumers and producers are strictly separated. Product categories exist where consumers also produce. But for example for food, production by producers and by consumers runs partially parallel (either growing one's own food or preparing). Other examples are home construction / improvement, car

[9] GEREFFI, G., HUMPHREY, J. & STURGEON, T. (2005) The governance of global value chains. Review of International Political Economy, 12, 78-104.

maintenance, clothing etc. Recently, we are witnessing a new trend of 'prosumers' (conSUMERS that are also PROducers), in which people individually or collectively (e.g. corporatives) are producing their own energy, food, technical refurbishments, but also services. This might dramatically shorten the chain and increase the influence and awareness of consumers with production in the chain. At the member state level, we see specific policy instruments for this group, for example the German feed-in tariff regulation.

2.3 Policy instruments for achieving circular product chains

In this section we will discuss the use of policy instruments and their application to address sustainability challenges in general and circular product chains in particular. We will first outline different instruments types, then discuss their role to resolve market failures, after which we will explain how they might affect links or reconstitute the product chain, and how effects travel through the chain. This section will discuss single instruments, the next section how to combine these.

2.3.1 Instrument types

Sustainability policy instruments in general and product related instruments in specific have been classified using various principles. An often used way of classifying product policy instruments is to the degree of authoritative force involved: regulatory, economic and informative (see table 2.3 below). Further, it is also possible to differentiate between policy instruments in terms of their mandatory or voluntary character. The former category refers to instruments with a clear binding character (e.g. laws), whereas the latter is framed by normative non-compulsory requirements or commitments (e.g. an environmental agreement between industry and a government).

One of the most widely used in the literature that describes the working mechanisms and effects of policy instruments[10] [11] [12]. Its strength is that the working mechanism is central to the classification and that also the voluntary and mandatory character is addressed.

Table 2.1 Categorisation of policy instruments and tools

Policy instruments	Mandatory instruments	Voluntary instruments
Administrative	Bans, licenses, requirement on EHS information, EPR, recycling and recovery quotas, material and quality requirements, emission levels, chemicals regulation	Responsible Care and similar initiatives, Product-oriented environmental management systems (POEMS), application of non-binding product standards, product panels, EMS, functionality panels, agreements between government and industry
Economic	Deposit-refund systems, taxes and charges, liability rules, subsidy and grants schemes	Green public procurement, technology procurement, R&D investments
Informative	Requirement on EHS information, emission registers, chemicals regulation on information for professional and private users, energy labelling, marketing regulations	Eco-labelling ISO type I, EPDs, green claims, energy labelling, organic labelling of food, certification schemes of e.g. hotels, consumer advice, consumer campaigns, education

Source: (Mont and Dalhammar, 2006)

[10] Sorrell, S (ed., 2001:30). Interaction in EU climate policy. SPRU, Brighton, UK, EU FP5 project number EVK2-CT-2000-0067

[11] Gupta, S., D. A. Tirpak, N. Burger, J. Gupta, N. Höhne, A. I. Boncheva, G. M. Kanoan, C. Kolstad, J. A. Kruger, A. Michaelowa, S. Murase, J. Pershing, T. Saijo, A. Sari, 2007: Policies, Instruments and Co-operative Arrangements. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, US

[12] OECD (2007), Instrument Mixes for Environmental Policy. OECD, Paris, France

All of these instruments can be used for stimulating circularity in products and product chains. However as we will discuss in the next subsection and sections, they each have specific effects through the chain and care should be taken when combining different instruments for the same chain.

2.3.2 Policy instruments in relation to economic markets

In the prevailing, neoclassical perspective the rationale for governments to apply these policy instruments is to overcome market failures, based on the principle that a free market is the best means to promote optimal societal welfare. This implies that the use of policy instruments must be minimized, unless a case can be made that a market failure exists that prevents that the market can do a proper job and that leaving things to the market ultimately creates lower welfare, as than a market guided by policy instruments. Table 2.2. gives examples of market failures.

Table 2.2 List of typical market failures (modified from [13] [14]).

Market failures	Explanation
Public goods	(i) one person's consumption of a public good does not reduce the amount available for consumption by others (non-rivalrous), and (ii) once a public good is supplied, it is available to be consumed by all of society (non-excludable). This makes it difficult to supply it via markets. Goods that are only non-excludable (common goods) also problematic as there is no market mechanism to moderate use (e.g. fish in the world seas)
Negative externalities	Third, non-involved parties experience positive or negative effects of a transaction between market parties or activities or market parties. In the sustainability field, negative externalities usually are the most important reason for policy intervention, since the environment is a common good that is not or insufficient subject to market forces
Positive externalities (split incentives)	An investor of an overall profitable investment is not able to reap (all) benefits, so that the investment is not done. A classic example is the lack of incentives for landlords to invest in energy efficient housing, since the tenant will reap benefits of less fuel use
Imperfect competition (monopoly, oligopoly, economies of scale, barriers to entry)	Weak competition leads to lower quality and higher priced products
Missing or incomplete markets	Certain services or goods cannot be provided by the market, such as unemployment insurance
Imperfect information / asymmetric information	Markets are not transparent, information is too complicated to understand, or too costly to obtain. The seller has more information on product (quality) as the buyer
Merit goods / equity	A commodity of which is judged that an individual or society should have on the basis of some concept of need, rather than ability and willingness to pay[15].

From the market failures listed in Table 2.2, in the field of ecological sustainability, externalities and common good problems are the most important. Individuals can reduce the quality of the environment at no to low costs for themselves, while creating drawbacks and losses for society as a whole. For instance, people buying and using products containing hazardous materials usually will not live close to the waste management facilities that treat or landfill end of life products and where emissions of hazardous content may take place. Societies using a lot of fossil energy and the countries creating most of the global warming problem may not be the ones most hit by impacts such as sea level rise. A typical example of common good problems is overfishing on the oceans: although all fishers would be better off to harvest only a sustainable amount of fish from the ocean, no market mechanism exist to divide this sustainable amount over

[13] EC (2009b) Impact Assessment guidelines. 15 January 2009, SEC(2009) 92

[14] Ledbury, Mark, Nigel Miller, Amy Lee, Tessa Fairman and Carla Clifton (2006). Understanding policy options. Home Office, London, UK, Report 06/06

[15] For instance, in times of food shortage (e.g. WW II) in a pure market a situation could arise where the poor cannot compete anymore for buying enough food. In such cases the market is superseded by a rationing system. Technically this is not a market failure, but it is a highly undesired outcome.

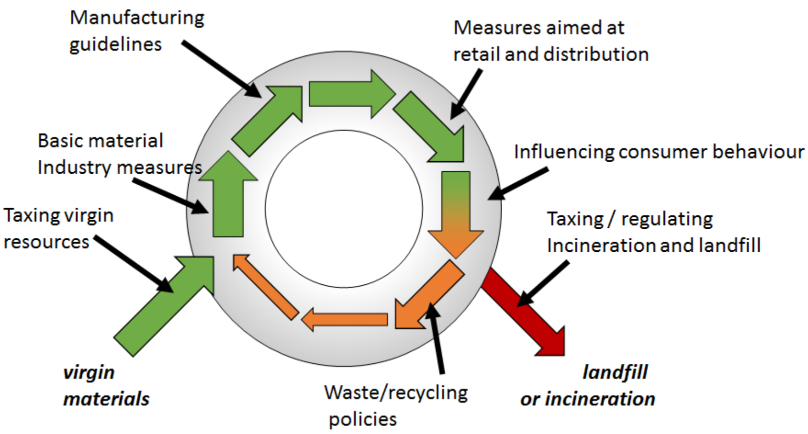
fishers (an example of the ‘tragedy of the commons’). When the environment is subject to such externalities or common good problems, protection via policy measures is the only way forward to prevent such externalities to occur.

As we will elaborate, between links in the product chain, other market failures may play an important role as well. For example consumers might be willing to pay extra for products using sustainable resources, but information asymmetry prevents them from being able to know which product (e.g. fish, wood) is sustainable. Certification is an instrument to solve this market failure (although it also creates a new asymmetry: consumers might not be able to distinguish between fully sustainable certification and limited or ‘window dressing’ certification). Imperfect markets can become inert to price signals: for example a monopolist might simply pass any economic incentive to reduce his ecological footprint on to the customer.

2.3.3 Policy instruments as intervention in links of the (circular) chain

If we look at policy instruments, these instruments usually intervene in a specific link in the chain (figure 2.4). For example a policymaker might decide to tax (or prohibit) landfill for certain materials; or encourage (or force) manufacturers to make products easier to take apart; or convince the consumer to separate waste. Many of these instruments do have intended and unintended consequences for the rest of the product chain. An intended effect of consumer campaigns might be a changing product preference of the consumer which will influence retail and in turn producers to change their products; or the taxing of virgin materials may lead to material conservation throughout the cycle.

Figure 2.4: Policy interventions along the value chain



A policymaker should typically consider two aspects in choosing an intervention point:

- The link where the effect (or efficiency) would be greatest: losses occur (or can be prevented) more at one point in the chain than others. For example: for manufactured goods, the costs for changing production to facilitate later recycling (design for recycling) can be much lower (and the benefits from a better quality much higher), than in the recycling phase investing in for example expensive separation equipment.
- The link where policy intervention is most feasible: for example, it might be much more feasible to tax or subsidize a few producers, or a material flow at the point of entry into the EU, than millions of consumers.

Eco-design policy paradox

These two intervention points do not necessarily coincide. For example: we might conclude the most cost-effective improvement in a chain is to have consumers repair products (instead of disposing them), but enforcing this through regulation would be virtually impossible. This problem holds especially for ‘eco-design’: redesigning manufacturing has often a high potential for both economic and ecological benefits, but it can be very complicated for policymakers to influence the intricacies of the design process of millions of products. There is a high risk of hampering creativity and innovation in design by regulation, thus achieving an opposite effect.

Indirect effects in the chain

Typically, policymakers will indirectly target design. For example, increasing the price of scarce or eco-damaging materials, will force the designer to make different trade-offs. Other examples of indirect effect in the chain are:

- Regulation in one link can set hard limits throughout the chain: for example prohibiting certain additives in materials, will force manufacturers to design products that do not need these prohibited materials. Regulation can also send economic incentives through the chain: for example if the production of one material is cheap but water polluting and the production of another material expensive but eco-friendly, compulsory water treatment facilities for the first production process, will make the make the eco-friendly approach more competitive.
- Information instruments are often directly aiming to solve information asymmetries through the chain. For example: ecological certification signals sustainability practices of producers to customers.
- Economic incentives in theory should also travel through the chain. For example, taxing fossil resources at production or import, should provide an incentive to producers and consumers, to switch to sustainable products. The other way around, if unsustainable food products would be taxed with a higher VAT, this would incentivize retail, traders and ultimately farmers to switch to sustainable production. As outlined before, in practice there might be market failures in the chain or demand might be highly inelastic.

The discussed structure of underlying industries will also play a role. In vertically integrated markets, trade-offs in the chain can be made within a single firm, but sunk investments in any link in the cycle could block innovation throughout the cycle. In highly liquid, competitive markets price signals might travel quickly through the chain, but integrative solutions might be difficult to coordinate. In chains characterised by long term relationships and power positions, suppliers might be not be in a position to pass incentives on towards the producer. In such cases, policy mixes are essential (see next section).

2.3.4 Extended producer responsibility as systemic instrument

Some policy instrument do not intervene at a particular link, but rather aim to reconstitute the organisation of the chain itself. A clear example is the ‘Extended Producer Responsibility’ (EPR), also called ‘take back’ regulation. In principle, this forces through regulation producers to take responsibility for the waste (or post-use) phase of their products. One could say, the chain is reconstituted by regulation to one of vertical integration.

In practice, this might not be the case. In contrast to the ‘take back’ slogan, in reality producers rarely actually take back their products (with the exception of some deposit systems). Producers typically do not consider it to be their core business to be involved in recycling and outsource this task to third parties, establish collective organisations or reach agree with public waste services to pay for public collection and recycling of their goods. This does achieve the ‘polluter pays’ principle and may incorporate some externalities of the product into the price of the product, and in this respect of arrangements are successful. It also involves to some extent producers more directly in dialogues about designing for recycling, as EPR expresses this is not a public, but a private task.

But EPR does not necessarily provide an economic incentive to individual producers to design for recycling. First, non-specific recycling systems are not necessarily able to reduce costs or achieve better results for design changes in the products of one producer. Second, even if recyclers would achieve better results for a specific product (for example avoidance of composite plastic materials), typical coarse-grained fee structures would not feed the benefits back to the specific producer. Third, EPR typically set mandatory minimum standards for quantity or recycling (and sometimes quality), but does typically not stimulate to perform beyond this minimum.

2.4 Policy mixes: theoretical insights about effectiveness and synergies

2.4.1 Introduction

In the previous we described the limitations of different types of instruments and interventions at different points in the product chain. In this section we will discuss how combining instruments might overcome these limitations and provide a more robust, powerful policy effect. Existing literature addresses when instruments have a synergistic or antagonistic effect, or simply are redundant and hence inefficient. We will review these for policy mixes that address the same actor at one point in time (2.4.2), different types of actors at the same time (2.4.3) and policy mixes that address the same actors differently over time (2.4.4). In 2.4.5 we will draw conclusions for circular product policy design.

2.4.2 Policy mixes focusing on the same actor(s)

The literature gives various principles for the application of policy instruments so that they work most effectively[16]. Such principles include:

- Avoid instrument overload – this creates the danger of redundancy or negative interactions. Ideally, the minimum set of instruments with maximum impact has to be used
- Use instruments that address the problem as broadly as possible, since this supports environmental effectiveness and economic efficiency. Maximise the flexibility in response measures of the targeted groups and device systems that allow for responses with lowest marginal costs. Economic incentives are vital in this respect.
- Mix instruments that ‘by nature’ are complementary for clear reasons, such as informative instruments with taxation (the informative instruments will enhance awareness and hence enhance the price elasticity of a product), and research and development support with economic instruments (sometimes the price gap is so high that research is needed to ensure a new technology or practice becomes more cost-effective)
- Avoid overlapping instruments: they reduce flexibility in response, or create simply confusion, while administrative burdens are enhanced.

Using such principles Sorrell[17] made a comprehensive review of when instruments interact positively and negatively. His review is provided in Table 2.3. He describes four ways how policy instruments can interact, mostly in line with the findings of the OECD above:

- Positive/Complementary. Examples are:
  - Informative instruments complement most other instruments while in themselves being inadequate in achieving objectives.
  - Negotiated agreements can complement administrative instruments, if the administrative instrument sets a minimum performance benchmark and the agreement is used to go beyond this benchmark

[16] OECD (2007), Instrument Mixes for Environmental Policy. OECD, Paris, France

[17] Sorrell, S (ed., 2001:30). Interaction in EU climate policy. SPRU, Brighton, UK, EU FP5 project number EVK2-CT-2000-0067

- Positive if sequential. For instance, in first instance a negotiated agreement is applied, that can be followed up by a tax or administrative instrument if targets are not met.
- Positive if beyond compliance. Here, an instrument like an eco-label could set more advanced standards as regulation, awarding product providers who go beyond compliance.
- Negative: one instrument limits unnecessarily the flexibility in response left by another instrument. Examples are standards (that de factor already determine responses) and environmental taxes, or sector emission standards in combination with an emission trading scheme
- Duplicative: the instruments simply overlap, which even without negative interaction is undesirable, since this contributes to an unnecessary regulatory burden.
- Contextual/Context specific: the interaction has to be judged case by case.

Table 2.3 Compatibility between different instrument categories (elaborated upon Sorrel, 2001)

		Informative	Economic			Administrative					
		Education and	Charge systems	Trading mechanisms	Financial instruments	Framework standards	Performanc e standards	Technology standards	Unilateral commitmen	Public voluntary	Negotiated agreements
Informativ	Education and information		Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive
Economic	Charge systems	Positive		Negative unless alternative	Contextual	Contextual	Negative (positive if sequential)	Negative	Contextual	Positive	Negative (positive if sequential)
	Trading mechanisms	Positive	Negative unless alternative		Contextual	Contextual	Negative (positive if sequential)	Negative	Contextual	Positive	Negative (positive if sequential)
	Financial instruments	Positive	Contextual	Contextual		Positive	Positive	Duplicative	Positive	Positive	Positive or duplicative
Administr	Framework standards	Positive	Contextual	Contextual	Positive		Positive	Negative	Positive if beyond	Positive	Positive if beyond
	Performance standards	Positive	Negative (positive if sequential)	Negative (positive if sequential)	Positive	Positive		Negative	Positive if beyond	Positive	Positive if beyond
	Technology standards	Positive	Negative	Negative	Duplicative	Negative	Negative		Negative	Negative	Negative
	Unilateral commitments	Positive	Contextual	Contextual	Positive	Positive if beyond	Positive if beyond	Negative		Contextual	Contextual
	Public voluntary schemes	Positive	Positive	Positive	Positive	Positive	Positive	Negative	Contextual		Positive or duplicative
	Negotiated agreements	Positive	Negative (positive if sequential)	Negative (positive if sequential)	Positive or duplicative	Positive if beyond	Positive if beyond	Negative	Contextual	Positive or duplicative	

If we reorder Sorrell's table into the categories of administrative, economic and informative instruments of subsection 2.3.2, we can draw some conclusions one combination of types of instruments:

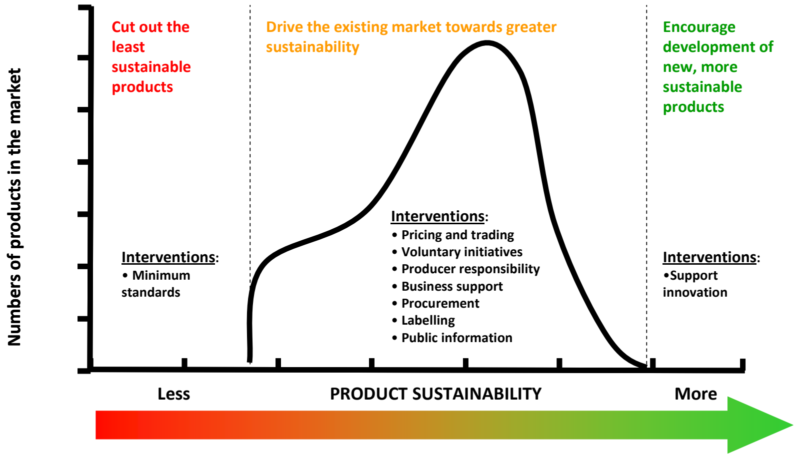
- Information instruments strengthen both economic and administrative instruments (although the usually are too weak to achieve results on their own).
- Administrative instruments in general combine with other administrative instruments. Technology standards however combine badly with any other instrument and public voluntary schemes' compatibility with other (administrative) instrument is very context dependent.
- Administrative instruments do in general not mix very well with economic instruments, with the exception of voluntary schemes (which mix well with economic instruments) and financial instruments (which mix well with administrative instruments).
- Economic instruments can be combined with other economic instruments, but it highly depends on the context and specific instruments used.

2.4.3 Policy mixes differentiating between products and between measures

Further, one has to recognise that product markets usually are populated by different products of which some already score well, and others score bad on an environmental aspect (see figure 2.5). This gives the opportunity to create synergies between instruments that to some extent also were identified by Sorrell[18], Hood[19] and OECD[20]:

1. Use mandatory administrative instruments to set a threshold for minimum performance of products.
2. Use voluntary initiatives, labels, green public procurement (GPP), informative campaigns and pricing mechanisms to reward products that go (well) beyond compliance.
3. Use R&D support to encourage new, breakthrough sustainable products not yet available on the market.

Figure 2.5 Push and pull interventions addressing the full pool of products in a specific market with different sustainability performance (from a presentation of Bob Ryder, DEFRA, Prague, October 2008)



Some care has to be taken to ensure optimal complementarity between measures under point 1), i.e. minimum performance standards, and certain measures under point 2), most notably labels, GPP criteria, and criteria used in pricing mechanisms. In all these cases environmental criteria or parameters with regard to the product at stake have to be assessed. It is quite obvious that optimal synergies are at stake when all these instruments use criteria based on the same indicator(s), that can be measured in the same way (e.g. energy use in the use phase, content of certain hazardous materials, etc.)[21]. This avoids confusion about differences in evaluation criteria across instruments, and simplifies testing, evaluation and assessment. Experience with for instance certification systems for coffee (Utz Certified, Rainforest Alliance) and labelling of wood products (FSC, others) show that a smart blend of even relatively weak instruments such as labels and voluntary initiatives can be very successful, exemplified by a 40% market penetration of certified coffee in the Netherlands and a 90% certification of wood production in Europe.

Differentiating between measures on the basis of costs

Similarly to differentiating between the sustainability of products, we could also take the perspective of the costs it would take to make products more sustainable. Hood (2010) suggests that typically three types of abatement options can be recognised along the cost curve that each need to be stimulated with specific policies. While Hood gives an example

[18] Sorrell, S (ed., 2001:30). Interaction in EU climate policy. SPRU, Brighton, UK, EU FP5 project number EVK2-CT-2000-0067

[19] Hood (2011), Combining Policy Instruments for Least-Cost Climate Mitigation Strategies. International Energy Agency, Paris, France

[20] OECD (2007), Instrument Mixes for Environmental Policy. OECD, Paris, France

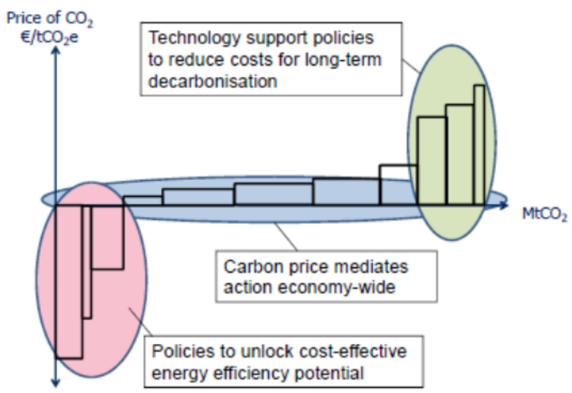
[21] Obviously, ecolabel or GPP criteria will be more stringent as minimum performance standards, but they still can apply to the same parameter (e.g. energy use in case of energy using products).

for climate action, it is not difficult to see the principle applies too to other environmental topics, such as realising a high level of resource efficiency (see figure 2.6):

a) Low hanging fruit' options with significant negative life cycle costs that however are not yet implemented. It concerns options where the initial investment in measures that reduce the environmental impacts, already can be gained back under existing market conditions (for instance: investment in energy saving technology leading to such savings in costs for energy use that the investment could be gained back quickly). If despite this positive economic picture the measure is still not implemented widely, there are apparently non-financial bottlenecks that hinder implementation of such measures. Dedicated policies are needed to overcome such market failures that lock the potential.
b) Options that have (moderate) net costs. In contrast to the former point, it concerns options where under existing market conditions the investment can *not* be gained back – making it rational for economic actors to leave things as they are. This situation clearly calls for deployment of financial instruments that internalize external costs (e.g. related to emissions), which can make the investment in measures that reduce environmental impacts profitable (for instance: a carbon tax).
c) Options that still are highly expensive. Here, the prohibitive cost of the available options for reducing environmental impacts is the key problem. In this situation, R&D and technology support is the way forward to speed up learning curves and lower costs.

Although less is known about the costs of circularity, we could expect a similar curve: some circular chains can already outcompete linear chains if a level playing field is established, power structures in the chain do not hamper innovation and producers are aware of this potential for profit. Other linear chains would need some incentives to transform to circular ones, to offset costs or to incorporate externalities and the full-scale transformation of a last group of linear chains could be expected to be presently prohibitively expensive.

Figure 2.6 GHG abatement cost curve and related policy strategies[22].



Transition instruments

Both the concepts discussed in this subsection take R&D stimulation towards sustainable products as long term policy. From transition studies literature [23] [24] [25](Rotmans et. al. 2001,

[22] Hood (2011), Combining Policy Instruments for Least-Cost Climate Mitigation Strategies. International Energy Agency, Paris, France

Rotmans and Loorbach 2009, Grin et. al. 2010), we might question if this fully covers the policy spectrum, as in many cases transformation of chains and industries underlying individual products is necessary. This requires not only product R&D, but also long term policies to change paradigms in industries, break-down institutional and other structural barriers and experiment with different economic and social models. Such system innovation approaches have as a goal to foster transitions towards sustainability in broad areas, such as the energy system, housing, food and mobility. Key concepts are adaptive learning, dealing with complex systems with emerging properties, etc. A key assumption in the transition management approach is that change cannot be planned, and that particularly in the initial stages hence a flexible learning strategy must be the answer. This approach is rather novel: the term ‘transition management’ was coined around 2000 in the Netherlands, and has been applied on broad scale mainly in that country. However many studies from an international, exponentially growing, research community are concluding that in many other developed countries, similar approaches are needed and past successes in policies for fundamental, long term change share characteristics with the policies prescribed by transition management.

2.4.4 Policy mixes differentiating over time

The latter subsection already hinted that as sustainable innovations in products and radical new, sustainable products mature over time and increase in market penetration, they require different policy measures (see Figure 2.7):

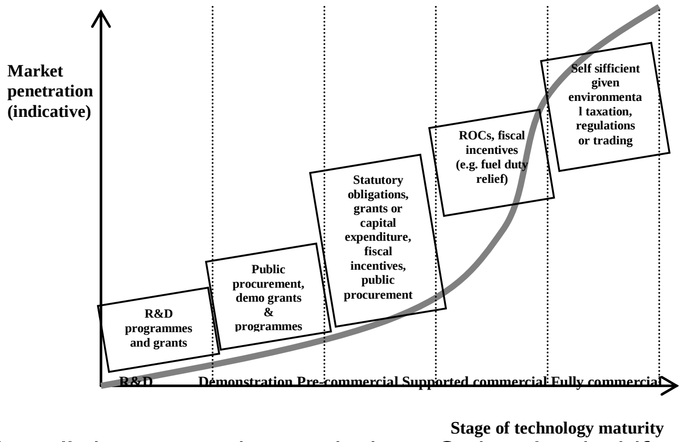
1. Initially, the new technology still needs development or experimentation. R&D programs and grants for development and testing are the most appropriate instruments in this stage.
2. In the next stage, when the technology or practice is sufficiently mature to be applied in practice, instruments that stimulate initial market penetration can be considered. Examples are fiscal incentives or GPP.
    a. Over time, the cost of the new technology or practice usually becomes lower. Once it becomes clear that the new technology or practice has major sustainability advantages and can be implemented broadly without excessive costs, its mainstreaming can be ensured via regulation (e.g. minimum standards such as the IED/BAT, Eco-design Directive), financial instruments, etc.

[23] Rotmans, Jan, René Kemp, Marjolein van Asselt, (2001) "More evolution than revolution: transition management in public policy", Foresight, Vol. 3 Iss: 1, pp.15 - 31

[24] Rotmans, J. & Loorbach, D.A. (2009). Complexity and Transition Management. Journal of Industrial Ecology, 13 (2), 184-196. doi: http://dx.doi.org/10.1111/j.1530-9290.2009.00116.x

[25] Grin, J., J. Rotmans and J. Schot (2010). Transitions to Sustainable Development. New. Directions in the Study of Long term Structural Change. New York : Routledge

Figure 2.7 Coordinated use of policy instruments in relation to the degree of technology maturity[26]



A well-documented case is how Switzerland shifted its agricultural system in a relatively short time to one of precision farming and organic farming[27]. Swiss retailers such as Migros and Co-op are co-operative firms in which ordinary citizens have significant influence on corporate policy. In the 1960s the articulation of problems with pesticides by the publication of the seminal book ‘Silent Spring’[28] lead to a demand to Migros and Co-op to have organic food in their shops. Various certification schemes for this were developed, and for a long time the market penetration of such food was less than a dozen percent. The main impact was that the Swiss agri-food system learned how to implement and (self-)regulate an alternative food chain. In the 1980s and 1990s though things changed dramatically. With the advent of the WTO, Switzerland was forced to abolish subsidies and other market protections for its agricultural sector. The main exemptions allowed were certain protective measures for sustainable farming. Faced with this financial incentive, the Swiss agricultural sector switched to precision farming and organic farming in a matter of years.

This example also relates to what we discussed before: sometimes changes at the level of chains or even entire industries are necessary, Rotmans et al.[29] have developed a multi-phase model of such transitions, distinguishing between (1) predevelopment; (2) take-off; (3) acceleration and (4) stabilisation. These phases bear some resemblance to the phases for individual technologies discussed above, but they are more than just the sum of individual technology policies, they also pay attention to change at the level of an industry, including paradigm shifts. The level of influence from policy on such large, fundamental changes is also less than on the level of individual technologies or measures.

2.4.5 Policy mixes for circular chains

Circular product policy is about intervening in (and along) a value chain. Different interventions at different points in the value chain can distinguished, that need to be well

[26] Foxon, T., R. Gross and D. Anderson (2003). Innovation in long term renewables options in the UK - overcoming barriers and system failures. ICEPT report for the DTI Renewable Innovation Review. London, Centre for Energy Policy and Technology Imperial College London (ICCEPT): 45

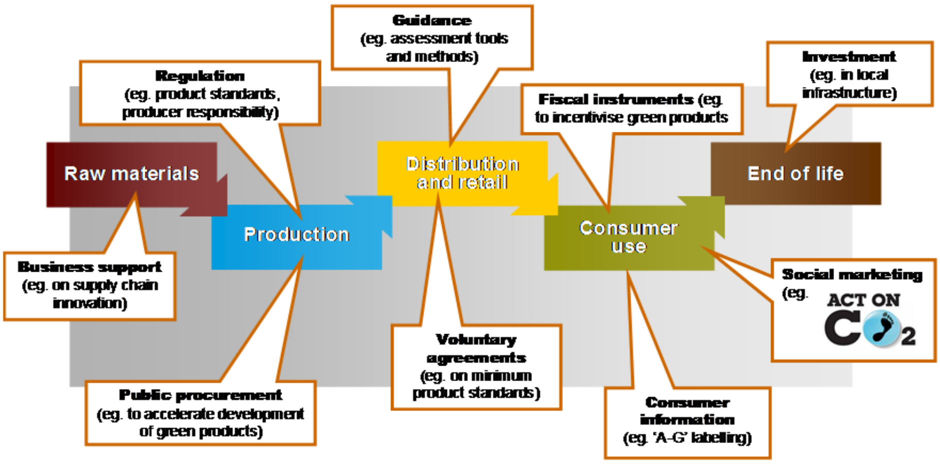
[27] Belz, F.-M. (2004). A transition towards sustainability in the Swiss agri-food chain (1970–2000): using and improving the multi-level perspective. In: Elzen, B., Geels, F.W., Green, K. (Eds.), System Innovation and the Transition to Sustainability: Theory, Evidence and Policy. Edward Elgar, Cheltenham,

[28] Carson, R (1962). Silent Spring, Houghton Mifflin (1962), Boston, MA, US: Mariner Books, 2002

[29] Rotmans, Jan, René Kemp, Marjolein van Asselt, (2001) "More evolution than revolution: transition management in public policy", Foresight, Vol. 3 Iss: 1, pp.15 - 31

orchestrated to be mutually reinforcing (see figure 2.8). For instance, regulation and public procurement could be applied to influence production and design, while information campaigns towards consumers can help buyer behaviour change.

Figure 2.8 Using a mix of policy instruments to change impacts of products at key life cycle stages (from a presentation by Bob Ryder, DEFRA, Prague, October 2008)



From the rich body of literature on combining instruments, discussed in the previous subsections, we can reflect on the effect of policy mixes in a circular chain. A first insight is that policy mixes are a 'necessary evil': applying too many instruments leads to very diffuse effects, confusion in industry about intent of government and conflicting instruments weakening the overall policy. As product chains cut through different industries, such a conflict can easily occur (as we will demonstrate in the cases). A simple example would be using a positive economic instrument to avoid an unsustainable material in a product, whilst another policy is already aimed at banning the material.

We also learnt from section 2.3 that complementary instruments might be needed, especially as the point where policy interventions are possible can be quite different from the point in the chain where measures can be taken and policy effects do not necessarily propagate throughout the chain. Given what we know about combining instruments, we might expect:

- Information needs to travel through the chain and we learnt informative instruments can very well be used to strengthen other instruments. Informative instruments are thus a key candidate for policy mixes.
- Mandatory administrative measures will typically not require additional measures, except temporary instruments to make industry aware of regulation and to smooth the adoption of an alternative practice, technology or material.
- Voluntary administrative measures might require additional policy instruments. Not only to make consumers aware, but we also learnt significant power asymmetries can exist in the chain. If producers in one link come to voluntary agreement, they might need aid (or the threat of mandatory measures) to avoid parties associated to other links in the chain to push for cost savings at the expense of sustainability.
- The same holds for economic instruments: price information in many cases will not spontaneously propagate through the chain and parties with power in the chain might resist economic incentives.

We discussed how instruments can be differentiated between products, a similar approach could be taken to links in the chain. Different industries in a product chain might be in a different situation. Like we could differentiate instruments between products' position on an environmental performance curve, we could distinguish between links in the chain that perform well and links in the chain that are lagging behind in environmental innovation.

Second, we might differentiate between entire chains, which could be informed by life cycle analysis. The least sustainable chains could be cut-out by repressive instruments, the most sustainable chains could be stimulated. R&D instruments could also be oriented towards chain cross-cutting innovation; instead of optimizing a single link in the chain. Instruments might also be developed that aim to transform entire chain-structures (and paradigms) to more sustainable chains.

2.5 Conclusions on theoretical research

To conclude, when thinking about a circular product policy one has to take into account two main factors: the configuration of the existing value chain, and under which circumstances policy instruments are synergetic.

With regard to the *value chain*, the economic picture as shown in Figure 2.1-2.4 is a basic point of departure. Since at some point in the chain materials get a negative value, it is difficult to re-introduce them at some point in the chain again as primary materials. While it is possible to use policy instruments to stimulate this uptake and hence circularity, there are factors in the value chain helping and hindering this. If there are high sunk tangible and intangible costs, particularly at a powerful node in the chain, change is difficult. If there is however reasonable technical flexibility or good prospects for incremental improvements at such a powerful node, one could use this node to push change through. An example of the latter is that implementing sustainable agricultural practices for e.g. coffee would just costs a minor mark-up price at the point of retail, a powerful node, and that retailers simply did not want to have the chance on negative publicity in relation to their supply chain. A rather simple instruments like voluntary certification changed the coffee market in years in many countries in Europe.

As for combinations of policy instruments, this chapter showed that a smart design of a policy package can produce a sum that is more than its parts. Positive synergies are usually at stake in the following situations:

1. Informative instruments in virtually all cases can support the working of administrative instruments (creating awareness about rule) and financial instruments (creating a higher willingness to buy the ‘green’ product and by this, enhancing price elasticity of this products). For circular products, this is especially important as information needs to travel between links in the chain.
2. When split incentives are at stake (e.g. the ‘landlord-tenant’ or ‘principal agent’ problem), usually two (or more) actors have to be addressed with tailor made instruments to create synergetic behaviour. For circular products, this might be investments in one link in the chain, that save costs elsewhere (e.g. better recyclability), but these improvements are not transparent throughout the chain.
3. When monitoring and compliance costs are high, sometimes an additional instrument can be developed that helps reducing such costs (e.g. a mandatory bookkeeping system). For circular products, such information need to be attached to the product and travel along the chain. Energy- and ecolabels are examples. Specifically for materials, new instruments like ‘resource passports’ might be needed.
4. In the case of product pools, hard administrative instruments can be very effective in realising a minimum performance standard. But this does not give any stimulus for improvement at the ‘market top end’. Other, softer instruments are be needed to stimulate continuous improvement of ‘beyond compliance’ products (informative instruments, fees, taxes).
5. The problem of how to realise more radical change needs probably the most attention. A systemic view and the use of sophisticated policy mixes are needed to overcome the ‘lock in’s’ that both industries as consumers face preventing them often to realise more than incremental changes. Examples are e.g. the high sunk costs in specific industries

(e.g. the chemical industry which cannot shift quickly to producing other chemicals) or life patterns of consumers (simply having work and house apart, making commuting an essential element of life). This leads to resistance that can be so strong that policy tends to implement just relatively soft measures. For radical change the policy mix is to be adapted over time according to stage of the change process (e.g. initially R and D support, stimulating front runners, embarking on joint learning by doing approaches, whereas later on more stringent instruments such as minimum performance standards or financial incentives can be considered).

The literature review also gives clear indications when instruments do not work effectively in combination:

1. Administrative standards and financial instruments (the administrative instrument determines already in full what action a regulated company has to take, and the financial instrument does not add value). This might sounds trivial, but for complex chains (and industries being involved in many different chains), such combinations could easily occur (and might even be somewhat unavoidable).
2. Administrative standards and negotiated agreements (unless used in sequence – in principle the negotiated agreement is aimed at, but administrative standards are to be applied should the negotiated agreement fail to reach its objective).
3. Financial instruments and negotiated agreements (idem).
4. Duplication of informative instruments (most notably proliferation of product labels) leading to confusion about environmental performance of products.
5. Duplication of policies and instruments at different administrative levels (leading to incoherent demands by different administrative levels)

3 Current EU- policies and instruments addressing product sustainability

3.1 Introduction

This introduction will describe the literature sources we used for making an inventory of product oriented instruments. We refer to box 3.1 below for a long list of studies we have used to make the inventory in this project.

Box 3.1: Studies inventorying and/or evaluating the effectiveness of policy instruments

- FP6-funded studies on SCP, in particular SCOPE2 (Sustainable Consumption Policy Effectiveness Evaluation; Lorek et al, 2009; Tukker et al., 2009) and ASCEE (Assessing the potential of various instruments for sustainable consumption practices and greening of the market;(Rubik et al, 2009), and SCORE (Sustainable Consumption Research Exchanges; Tukker et al., 2008)
- FP7-funded studies on SCP (e.g. EUPOPP: Adell et al., 2010, etc.)
- FP7 studies on reduction of energy use from a consumption perspective (BARENERGY and Changing Behaviour)
- European Environment Agency studies: SCP country fact sheets Europe and Resource Efficiency in Europe (with country fact sheets) (http://scp.eionet.europa.eu/facts/factsheets_scp, accessed 4 November 2011)
- OECD work on SCP and product policy, with reviews on policies for SCP and eco-innovation (e.g. OECD, 2011)
- Studies at the Member State level, such as the 4E approach developed by DEFRA (DEFRA, 2010, SCR, 2006)
- Other studies such as the ones commissioned by the EC and German Ministry of the Environment e.g. IOW for environmental product policy for the EC, GTZ/CSCP study on SCP and Resource efficiency, (GTZ, 2006), etc
- European Environment Agency (2011). Resource Efficiency in Europe. Polices and Approaches in 31 EEA member and co-operating countries. EEA, Copenhagen, Denmark
- TNO/Bio Intelligence for DG JRC IPTS (2012): Review of product policy instruments for the EU

Using the classical division in administrative, economic and voluntary instruments table 3.1 reviews a fairly comprehensive overview of instruments related to product policy. The table also identifies a few instruments applied in member states, if they can give illustrations of how they could contribute the development of a possible circular product policy. This is for instance the case with economic instruments that cannot be applied at EU level since the mandate of such instruments lies with the Member states. We further decided to focus not only at instruments dealing with circularity, but product sustainability in general since the aim of this report is to analyse how policy mixes can be optimized.

As indicated in chapter 2, we wanted here to have an analysis that places instruments in the various parts of the value chain discerned in chapter 2 (resources, manufacturing and product design, packaging, distribution and retail, consumers, waste management, and the chain as a whole. Table 3.1 also indicates in which chain part we placed the instrument. We then discuss the instruments, their working mechanism, and information on effectiveness by part of the production-consumption chain in the next sections.

Table 3.1 Main types of policy instruments found in literature review

Administrative mandatory	**Main environmental aspect addressed**	**Key examples at EU or MS level**	**Chain part**
General	Can be all	EU Environmental liability Directive	Manufacturing and design
Product standards	Can be all, though in practice most instruments focus on Energy	EU Eco-design/EuP directive EU Energy performance of buildings directive EU Directive on emission performance standards for new passenger cars EU Directive on type approval of motor vehicles with respect to emissions Mandatory share of biofuels in fuel (P)	Manufacturing and design
Product bans	Can be all, though in practice most instruments focus on Hazardous content	EU RoHS Directive EU REACH Directive	Manufacturing and design
Waste targets (e.g. prevention, recycling, take back obligations)	Waste	EU WEEE Directive EU Packaging Directive EU End of Life Vehicles Directive *Extended producer responsibility for packaging, etc. (PL)* *Various other waste management instruments at EU level*	Waste management Packaging Waste management Waste management Waste management
Other (e.g. process standards)	General/can be all	IPCC Directive	
Administrative, voluntary			
Green Procurement	General/can be all	EU Guidelines on GPP	Distribution and retail, consumers
Voluntary agreements (including self-enforcement and monitoring	General/can be all	Voluntary agreements (e.g. elf-commitments of EICTA and CEDEC on domestic appliances) EMAS *Utz Certified (Coffee)*	Manufacturing and design
Economic, mandatory			
Ecotaxes on products	General/can be all	Environmental taxation: High VAT or tax on 'grey' products, limited VAT or tax on similar 'green' products	Distribution and retail, consumers
Deposits	Waste, materials	*Deposit for one way beverage packaging (GER)*	Packaging
Subsidies and incentives	General/can be all, though Energy dominates	*Subsidies for specific 'green' products (e.g. solar cells)*	Distribution and retail, consumers
Minimum prices	General/can be all, though Energy dominates	*Feed in tariff (GER)*	Consumers
Other (e.g. process emission	General/can be all	EU Emission Trading Scheme	Manufacturing and design

Administrative mandatory	Main environmental aspect addressed	Key examples at EU or MS level	Chain part
taxes, cap and trade)		*Waste water from point sources according to level of pollution, various MS*	
Economic, voluntary			
•R&D support, advice	General/can be all	Innovation vouchers CIP Market replication EU ETAP, EU FP7, Environment, Energy and other programs	Integrative
Others	General/can be all	*Tax compensation for investment in green funds (NL)*	
Informative, mandatory			
Product labels	General/can be all though Energy dominates	EU Energy labelling Directive (Domestic Appliances)	Manufacturing and design
Informative, voluntary			
Product labels (usually combined with certification and tracking systems)	General/can be all	EU Ecolabel EU Organic label	Distribution and retail, consumers
Joint visioning	General/can be all	Product roadmaps for 10 product groups (UK – EEA, 2011)	Manufacturing and design
Learning materials and networks	General/can be all	European Technology Platforms OECD Sustainable Manufacturing Toolkit *MilieuCentraal (NL)*	Manufacturing and design
Awards	General/can be all	*DEMEA Material award scheme (D – EEA, 2011)*	Manufacturing and design
Media, Campaigns, Newsletters, Brochures; Education material, Electronic media, other	General/can be all	*Various media campaigns (all MS, EU)*	Distribution and retail, consumers
Other			
Public service companies	In practice: waste, energy	*SMILE – waste to resource exchange brokerage (IE – EEA, 2011)*	

3.2 Instruments addressing producers

3.2.1 Instruments addressing (virgin) resources

Our inventory did not find instruments addressing virgin resources specifically. Many of the instruments addressing manufacturing and product design (next section) are however relevant for the extraction of primary resources too, such as the EU Industrial Emissions Directive, the EU Environmental Liability Directive, and a number of voluntary administrative instruments in the form of voluntary certification schemes aimed at primary resources, such as the Forest Stewardship Council (wood), Marine Stewardship Council (fish) and Utz Certified (coffee, cacao, others).

3.2.2 Instruments addressing manufacturing and product design

Instruments addressing manufacturing and product design at EU level, with some additional examples at Member state level, include the following:

1. EU environmental Liability Directive
2. EU RoHS Directive
3. EU REACH Directive
4. EU Industrial Emissions/IPPC Directive
5. EU Eco-design/ EuP Directive
6. EU Energy Performance of Buildings Directive
7. Voluntary agreements
8. Eco-management and Audit Scheme
9. Subsidies for specific green products (Green Funds Scheme NL)
10. Innovation Vouchers

Their main aim, the environmental aspects addressed, working mechanism, and experiences on effectiveness are discussed in the table below.

	Main aim	**Environmental aspects addressed**	**Working mechanism, potential, exploitation**	**Experiences on effectiveness and side effects**
Administrative, mandatory				
EU environmental Liability Directive	The aim of the instrument is to ensure that economic operators are liable and need to financially compensate and/or remediate environmental damage they cause	The Directive covers environmental damage in general	See aim. The focus of the instrument is production rather than products. EU MS have to implement the Directive in national law	Slow implementation by MS, no conclusive literature on impacts
EU product liability directive 85/374/EEC	Establishes strict liability of producers for defective products	(excludes environmental damages, but includes damages caused by products to health (Eg. Toxic chemicals) with almost no restrictions)		[

	Main aim	Environmental aspects addressed	Working mechanism, potential, exploitation	Experiences on effectiveness and side effects
EU RoHS Directive	RoHS prohibits the use of certain hazardous substances in domestically produced or imported Electrical and Electronic Equipment	Hazardous content	See aim. The Directive forces producers to redesign their products. In case of clear concern, RoHS could be expanded to other hazardous substances	Enforcement problems apart, the Directive is highly effective being a mandatory instrument. It lead to significant reductions of use of hazardous substances in EEE
EU REACH Directive	REACH obliges companies to provide information on how they manage the risks that chemicals can pose to human health and the environment	Hazardous content and indirectly Waste	Companies must register substances filing a dossier with the European Chemicals Agency (ECHA). If risk reduction is required in specific applications, other instruments are used to ban use in specific applications	Limited insights. REACH however leads to a higher level of information of risks of substances as under past legislation
EU Industrial Emissions / IPPC Directive	The objective of IPPC is to prevent emissions into air, water or soil of about 50,000 large industrial installations across the EU27	The Directive focuses on production. There, it aims to address energy and material efficiency and hazardous content and hazardous emissions.	MS are required to set up a perming system. BREFs give guidance on Best available technologies.	An EU evaluation (ENTEC, 2009) revealed various problems such as different levels of BAT implemented, higher compliance costs for operators, some efficiency improvements, etc. More flexible instruments such as ETS for pollutants could work more cost effective.
EU Eco-design/ EuP Directive	The Directive aims to ensure that the products covered by the Directive have a minimum energy performance	Currently the Directive covers Energy us, although it can be expanded to other aspects	See aim. For about a dozen products implementing measures have been taken, with a few other dozen considered in Work Plans for further years	Limited experiences, due to the recent implementation. Impact however should be high given the mandatory nature of the instrument
EU Energy Performance of Buildings Directive	The EPBD requires Member States to set up and apply minimum requirements of energy efficiency of new and existing buildings	Energy use	See aim. Setting energy performance standards is left to MS. Existing buildings are only covered in case of renovation of over 1000 m2 floor space.	Limited insights. In general such regulation stimulates (eco)innovation. Improvement possible by guidance on performance standards at EU level and expansion to existing buildings
EU Emission (fleet) standards for cars	Limits emissions. In addition regulates emission control devices, fuel consumption information etc. Appears to provide options for financial incentives policies at member state levels	Energy use / CO_2 emissions, other emissions?		
Administrative, voluntary				
Voluntary agreements	Voluntary agreements in essence imply a negotiated agreement between government and industry sector or similar group, or an own initiative from an industry or similar group, to commit themselves to specific environmental targets.	In principle all environmental aspects can be covered	Voluntary agreements can often be a relatively easy to implement and flexible first step to realise environmental performance targets in a certain area, to be followed by 'hard' legislation if not effective	The most effective VA's include third party control and sanctions. Some VA's simply are greenwash by the private sector.

	Main aim	Environmental aspects addressed	Working mechanism, potential, exploitation	Experiences on effectiveness and side effects
Eco-management and Audit Scheme	An EMAS registration allows organisations to demonstrate to stakeholders such as customers, regulators, and citizens that they evaluate, manage and reduce the environmental impact of their activities.	In principle all environmental aspects can be covered	For obtaining and EMAS registration, a company must (1) conduct an environmental review, (2) adopt an environmental policy, (3) establish an EMS, (4) carry out an internal environmental audit, (5) prepare an environmental statement, (6) independent verification by an EMAS verifier, (7) register with the Competent Body of the Member State, and (8) use the verified environmental statement	EMAS has a positive influence on environmental process and product innovations
Economic, voluntary				
Subsidies for specific green products (Green Funds Scheme NL)	Private investors provide green projects selected by the government with capital and are rewarded by a lower tax on financial assets	In principle all environmental aspects can be covered	See aim.	At the start finding suitable projects was hard. Other observed obstacles included problems in the cooperation between supervising ministries, maximum investment sums for private investment being too low, lacking knowledge among the general public and hold-up problems with regard to future government policy
Innovation Vouchers	Innovation vouchers are (small scale) funding schemes used in national or regional systems of innovation to help companies to innovate, e.g. focusing on eco-innovation	In principle all environmental aspects can be covered	Innovation vouchers are administered by an innovation intermediary at the regional or national level, but funding often comes from the EC (e.g. Regional Funds).	Evidence on the effectiveness of the scheme is patchy and varying. Schade et al (2009) found that the vouchers do not generate the expected impact if services are too vaguely described and are not linked to clear objectives.

3.2.3 Instruments addressing packaging

Instruments addressing packaging at EU level, with some additional examples at Member state level, include the following:

1. EU Packaging Directive
2. Deposit for One-Way Beverage Packaging (GER)

Their main aim, the environmental aspects addressed, working mechanism, and experiences on effectiveness are discussed in the table below.

	Main aim	Environmental aspects addressed	Working mechanism, potential, exploitation	Experiences on effectiveness and side effects
Administrative, mandatory				
EU Packaging Directive	The Directive in essence sets minimum targets with regard to recycling and re-use of packaging waste	Waste	Member states have to ensure the minimum re-use and recycling targets are met.	Overall, the packaging recycling and recovery targets have been largely met
Economic, mandatory				
Deposit for One-Way Beverage Packaging (GER)	The main goal of the policy instrument applying a Deposit for one-way beverage packaging (German: Einwegpfand or in popular use Dosenpfand) is to reduce waste and litter resulting from the use of beverage cans and bottles	Waste	The instrument works very simple: when one buys a beverage, a deposit on the packaging is paid, and the deposit is returned when the packaging is collected by a shop.	The German Deposit scheme is highly effective: experts estimate that since 2006 the non-return rate of containers has decreased until about 5 percent

3.2.4 Distribution and retail (including virtual firms)

Instruments addressing distribution and retail at EU level, with some additional examples at Member state level, include the following:

1. EU Guidelines on Green Public Procurement
2. EU Energy labelling directive
3. EU Eco-label
4. Organic label
5. Environmental taxation

Their main aim, the environmental aspects addressed, working mechanism, and experiences on effectiveness are discussed in the table below. It has to be noted that most of these instruments try to address consumer preferences, and in this way influence distribution and retail. At the same time it appears that distribution and retail in many branches is a power node, and ‘choice editing’ by retailers and distributors (i.e. pre-selecting sustainable products to be on the shelf) often is equally important as the direct influence of consumer choice.

	Main aim	Environmental aspects addressed	Working mechanism, potential, exploitation	Experiences on effectiveness and side effects
Administrative, voluntary				
EU Guidelines on Green Public Procurement	The EU GPP guidelines should help authorities to include green procurement criteria in their procurement procedures	In principle all environmental aspects can be covered	The guidelines for 18 products help authorities to embark on GPP.	Only 7 MS practice significant GPP. Guidelines should focus on priority products bought by authorities. Voluntary agreements with different organisations relevant for GPP (e.g. Covenant of Mayors) could be pursued
Informative, mandatory				
EU Energy Labelling Directive	The main aim of the EU Energy Label is to make energy use of domestic appliances and electronic goods transparent to the public.	Energy use	Producers should determine and publish energy use for designated products. Each product should bear a specific category label reflecting the energy performance of the product. This provides producers with incentives to be 'best in class' and consumers to buy the product with the best energy performance. Retailers have to display this label.	The label is effective, over 90% of the products are now A class. Limitations are however that the requirements for the high classes do not change so that by now no differentiation is possible between products. Adding classes (A+,A++,A+++) confuses the consumer.
Informative, voluntary				
EU Eco-label	The label in essence ensures to the consumer that the product is among the top performers in its class with regard to the most relevant environmental aspects for that product	In principle all environmental aspects can be covered	Criteria are set up for each product group. A producer can apply for the EU Ecolabel at the national Competent Body which verifies the product	Some evidence of increase in the market share of ecolabelled products. Concerns about administrative costs, competition of green self-claims / label proliferation, no sound monitoring of market penetration
Organic label	The label in essence ensures to the consumer that the product is produced according to organic principles	Biotic resource use, hazardous content	The Directive sets criteria. A producer can apply for the EU Ecolabel at the national Competent Body which verifies the product	Since the year 2000, the market for organic food currently represented 1.5% of all EU food sales (EEA, 2001), to about 4% in 2010
Economic, mandatory				
Environmental taxation	Differentiated environmental taxation such as differentiated VAT is to stimulate supply and demand of environmentally friendly alternatives within a specific product group	In principle all environmental aspects can be covered	The instrument reduces prices of environmentally friendly products	Effects\ are highly depending on both how the VAT subsidy is calibrated in terms of product coverage, energy efficiency and other environmental requirements, as well country specific circumstances

3.3 Instruments addressing consumer behaviour

Most of the instruments addressing distribution and retail in fact do so by trying to influence consumers as well. Instruments addressing manufacturing and product design at EU level, with some additional examples at Member state level, include the following:

1. Feed in Tariff (GER)

Their main aim, the environmental aspects addressed, working mechanism, and experiences on effectiveness are discussed in the table below.

	Main aim	Environmental aspects addressed	Working mechanism, potential, exploitation	Experiences on effectiveness and side effects
Economic, voluntary				
Feed in Tariff (GER)	The instrument in essence implies that if private actors invest in the production of renewable energy, such as via solar cells, they are guaranteed a specific price for the energy generated	The specific instrument of the feed-in tariff has been developed to stimulate renewable energy production. It hence mainly relates to the environmental aspect energy use.	See aim. The remuneration system applies to a 15-20 year period to avoid hold-up; a short term feed-in tariff guarantee would keep private parties from investing in the necessary equipment	Especially Germany has achieved significant increases in the share of renewables production in total energy supply, and this boosted a renewable energy sector of 170.000 persons

3.4 Instruments addressing waste recycling, landfill and incineration

Instruments addressing waste management at EU level, with some additional examples at Member state level, include the following:

1. EU WEEE Directive
2. EU End of life vehicles Directive

Their main aim, the environmental aspects addressed, working mechanism, and experiences on effectiveness are discussed in the table below.

	Main aim	Environmental aspects addressed	Working mechanism, potential, exploitation	Experiences on effectiveness and side effects
Administrative, mandatory				
Waste Directive (2008)	General framework for waste reduction, re-use, recycling and disposal, could also be seen as systemic instrument			

	Main aim	Environmental aspects addressed	Working mechanism, potential, exploitation	Experiences on effectiveness and side effects
EU WEEE Directive	The WEEE Directive sets targets with regard to reuse and recycling of Waste from Electrical and Electronic Equipment	Waste, and indirectly hazardous content	WEEE asks for minimum recycling and re-use targets to be met. MS must ensure that they or producers / importers set up collection and recycling systems. The system sets mass based targets, for small flows of 'critical materials' dedicated targets can be considered	The WEEE is a mandatory administrative instrument that if enforced properly will result in the legal minimum standard for recycling, re-use and treatment. Concerns are potentially large fractions shipped as secondary products abroad
EU End of life vehicles Directive	The Directive in essence sets re-use and recovery targets for ELV and make producers responsible for the costs of waste management. Vehicles should be depolluted before treatment	Waste and hazardous content (related to the depollution issue)	The Directive seeks to make producers responsible for the cost to take back their products. Targets are getting more stringent in 2015	Many MS saw delays in implementation. Despite these problems, available figures show progress towards the reuse, recovery and recycling targets (EC 2009, GHK 2006).
End of Waste regulation	Regulations to ensure waste regulations apply until waste is recycled into useful, safe materials (or safely disposed of).			
1991/31/EC Landfill of Waste	Regulation for environmentally safe landfills (e.g. not mixing hazardous and non-hazardous waste), but also prohibiting certain waste streams to be land-filled (e.g. tyres)		[Table to be completed]	
Shipments of waste	Various levels of restrictions and reporting requirements to move waste within the EU, to other developed countries and especially to non-OECD countries			
Re-use of sewage sludge in agriculture	Such re-use is an example of circularity, the main focus of the legislation is however on health protection.			
Various specialist regulations	E.g. on radioactive waste, re-using sludge, ship waste and dismantling, mining waste. PCB's			
Informative				

	Main aim	Environmental aspects addressed	Working mechanism, potential, exploitation	Experiences on effectiveness and side effects
Statistics	Framework for EU statistics on generation, recovery and disposal of waste			

3.5 Integral instruments

Finally, there is a number of broad instruments including

1. CIP eco-innovation market replication programme
2. EU Environmental Technologies Action Plan
3. EU Lead Markets Initiative

Their main aim, the environmental aspects addressed, working mechanism, and experiences on effectiveness are discussed in the table below.

	Main aim	Environmental aspects addressed	Working mechanism, potential, exploitation	Experiences on effectiveness and side effects
Informative, voluntary				
EU Lead Markets Initiative	Lead market initiative aims to create stepping stone first market for an eco-innovation. It probably has to be classified as an instrument mix than a single instrument	In principle all environmental aspects can be covered	See aim.	Limited hard evidence and evaluations on impact
CIP eco-innovation market replication programme	The CIP Eco-innovation program is a funding scheme that aims to bridge the gap between research and the market by helping to turn ideas for innovative products, services and processes that protect the environment become fully-fledged commercial prospects, ready for use by business and industry	In principle all environmental aspects can be covered	See aim	To date there is no formal evaluation of the effectiveness of this policy instrument
EU Environmental Technologies Action Plan	ETAP aims to stimulate eco-innovation and operates at a different level as all other instruments reviewed until now. It is probably best to regard ETAP as an umbrella under which various other instruments are combined, as an instrument in itself	In principle all environmental aspects can be covered	See aim	The impact assessment of this plan was scheduled for the first quarter of 2010 but it has not yet been made publicly available.

Some instruments in specific links in the chain do have elements of an integral instruments in them. For example the waste directive, mainly deals with the waste phase, but also explicitly deals with redesign and re-use. Similarly, the packaging directive addresses packaging design and use of recycled material in packaging.

3.6 Conclusion on inventory of existing instruments

This chapter provided an overview of existing policies that related to circularity or sustainability in general. This overview confirms that EU circular policies are already in effect for decades for many different products and industries. We further observe:

- In many cases policy mixes of for example economic, administrative and communication can be observed, but within these mixes administrative instruments appear to dominate.
- Even though many EU policy instruments relate to circularity, most environmental policy instruments focus on themes such as waste management, energy, climate, pollution, hazardous chemicals or environmental health and only some are integral or focus on circularity.
- For some type of products or industries, a high intensity of policy instruments can be noticed, whereas for other policy instruments are more sparse (and do not constitute policy mixes). It appears EU policy is thus in its operational instruments fragmented.
- Some instruments have the explicit ambition to be integral over the material or product cycle, but a focus on the waste phase can be noticed and a relative void of instruments focusing on the resource phase.

We will elaborate on these observations and formulate recommendations in the final chapter 6, but first we will enrich this broad overview by four specific case studies (chapter 4) and a reflection on mechanisms to accelerate or slow-down the effects of policy instruments on the transition to a Circular Economy.

4 Product case studies into effectiveness of present EU policies and opportunities for new policy.

4.1 Introduction

To explore more in-depth the current circularity of the European economy, the existing policy instruments and the opportunities for further circular EU policy instruments, we have conducted desk research into four case studies. These case studies have been selected to together address the diversity in EU products such as biological and technological materials, different supply chain and industry structures, topics with already heavy EU policy involvement and products only indirectly affected by EU policy, and lastly supply and waste chains that are within the EU and chains that are largely global. These cases are:

- **Electric and electronic equipment (EEE),** which contains many different technological materials (such as iron, copper and relative small quantities of rare earth metals) which are considered critical resources by the EU. EEE has international supply chains, but also significant production inside the EU and is heavily environmentally regulated by the EU already.
- **Synthetic textiles,** is an area which is barely directly addressed by EU policy, but nevertheless demonstrates strong circularity with economic value in some aspects. Supply chains are long and cut through many global and local industries. Little physical production remains in the EU, but the EU does have a significant retail and fashion industry. By definition these materials are technological, but they interact with natural textile materials (such as cotton).
- **Construction of buildings** is largely organized on a local and national scale and is an industry characterized by many small scale players and diffuse power relations. Construction uses large amounts of biological and extractive materials such as concrete, copper and iron.
- **Wood products** can have both complete supply chains in the EU (softwood) and international supply chain (hardwood). Softwood is a strong example of autonomous drivers creating a circular economy, making the ‘golden oldie’ of wood an example for other materials. This Circular Economy is however potentially negatively affected by (policies stimulating) the energy transition.

Each of the case studies will first discuss the physical flows in the product chain, after which we will sketch the market(s) structure. Subsequently we will identify strengths and challenges for the product chain and discuss to which extent current EU policy addresses them and which new middle and long term instruments might be needed. In chapter 5 we will reflect upon the wider institutional and economic context in which these cases take place.

4.2 Electrical and Electronic Equipment

Production and use of EEE have significantly increased during the last three decades; electronic devices and new applications have become a part of everyday life due to technological innovations. This has also led to the rapid growth of waste electrical and electronic equipment (WEEE). The large amounts and complex mixture of materials and hazardous substances contained in EEE have raised concerns over environmental and health impacts of WEEE. While hazardous substances present in electronic equipment are not likely to be released during their regular use, they may pose hazards during waste treatment and disposal.[30]

This case study, like subsequent case studies, commences with a short outline of the electronics product chain and EEE (waste) issues in the EU, both from a physical perspective of flows and conversions (4.2.1) and a market structure perspective (4.2.2), from which we will conclude upon the strengths and challenges for a circular product chain (4.2.3). Subsequently, EU policy instruments in the various links in the chain are discussed (4.2.4). Finally, we will identify opportunities for potential policy improvements on the middle term (4.2.5) and explore long term policy issues (4.2.6).

4.2.1 Material flows and conversions in the EEE product chain

Electrical and electronic equipment is a very broad category, encompassing glossy smart phones to powerful electrical machines and from lamps to medical devices. We will provide a simplified overview of the typical product cycle.

4.2.1.1 Raw Material extraction

Development of new EEE applications have led to a situation where several critical materials have a vital role in electronics, resulting in a concern about their sufficiency and vulnerability of supply. As shown in Table 4.2.1, easy retrievable deposits in the Earth's crust are substantially declining.[31] As discussed, in practice we do not simply run out of such materials, but prices on average rise and become whimsical as the market is unable to smoothly match inelastic demand to inelastic supply.

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[30] Paragraph based on: Ylä-Mella, J., K. Poikela, U. Lehtinen, P. Tanskanen, E. Román, R. L. Keiski, and E. Pongrácz. 2014. *Overview of the WEEE Directive and Its Implementation in the Nordic Countries: National Realisations and Best Practices*. Journal of Waste Management Volume 2014: 457372. http://dx.doi.org/10.1155/2014/457372.

[31] McCann, D. and A. Wittmann. 2015. *Solving the E-Waste Problem (Step) Green Paper: E-waste Prevention, Take-back System Design and Policy Approaches*. www.step-initiative.org/files/step-2014/Publications/Green%20and%20White%20Papers/Step%20Green%20Paper_Prevention&Take-backy%20System.pdf.

Critical Resource use in Electronics and Years of consumption remaining in global reserves

Metal	Use in electronics	World mine production	% Demand for production of EEE	Years of reserves left at today's consumption	Years of Reserves left at half of US per capita consumption rate	% of consumption met by recycled materials
Silver	Contacts, switches, lead-free solder, conductors, etc.	20,000 tonnes per year	30%	29	9	16%
Gold	Bonding wire, contacts, etc.	2,500 tonnes per year	12%	45	36	43%
Tin	Lead-free solder	27,5000 tonnes per year	33%	40	17	26%
Copper	Cables, wires, connectors, PCBs, transformers	15,000,000 tonnes per year	30%	61	38	31%
Indium	Flat screen displays, semiconductors	480 tonnes per year	79%	13	4	0%

Source: StEP – from e-waste to resources (2011), New Scientist (2007), US Geological Survey Mineral Commodity Summaries (2007)

Table 4.2.1: Critical resource use in electronics

Especially the EU does not have reliable and undistorted access to certain raw materials. EEE uses a number of largely imported bulk materials such as crude oil for plastics and ore for steel, copper for cables, and a number of high valuable, scarce metals (see table 4.2.1). Half of the 20 EU designated critical materials (EU critical materials report 2014), have significant applications in EEE (table 4.2.2, dark grey) and for another a small fraction of total imports are used in EEE (light grey).

Antimony (semiconductors,)	Beryllium (electronics)	Borates	Chromium	Cobalt (batteries)	Coking coal (steel production0029	Fluorspar
Gallium (IC's, LED's)	Germanium (telecommunication equipment, LEDs)	Indium (flat panel, batteries, Led, solder)	Magnesite	Magnesium	Natural graphite (carbon brushes, batteries)	Niobium (capacitors)
Platinum Group Metals	Phosphate rock	Rare Earths (heavy) (LCD) (motors)	Rare Earths (light) (batteries)	Silicon Metal (electronics and semi-conductors)	Tungsten (lighting)	

Table 4.2.2: use of EU critical materials in EEE (based upon Critical Materials Profiles, 2014, DG Enterprise)

4.2.1.2 Component/Final Product Manufacturing & Distribution

According to the Solving the E-waste Problem (StEP) initiative, the total EEE put on the market in the EU was around 10 Mt in 2012.[32] This corresponds to an average of 19.4 kg/inhabitant. The dominant product categories in the EU are (from large to small share): large household appliances, IT and telecommunication equipment, consumer equipment and small household appliances.[33] As Figure 4.2.1 points out, significant volumes of electronic equipment are imported into the EU. Figure 4.2.1 shows the trade flows of EEE products between EU-27 and 5 regions of the world in 2012, showing the specific trade flows of these commodities between the different regions. Quite noticeably, around 3 Mt of EEE was imported from Asia into the EU.[34]

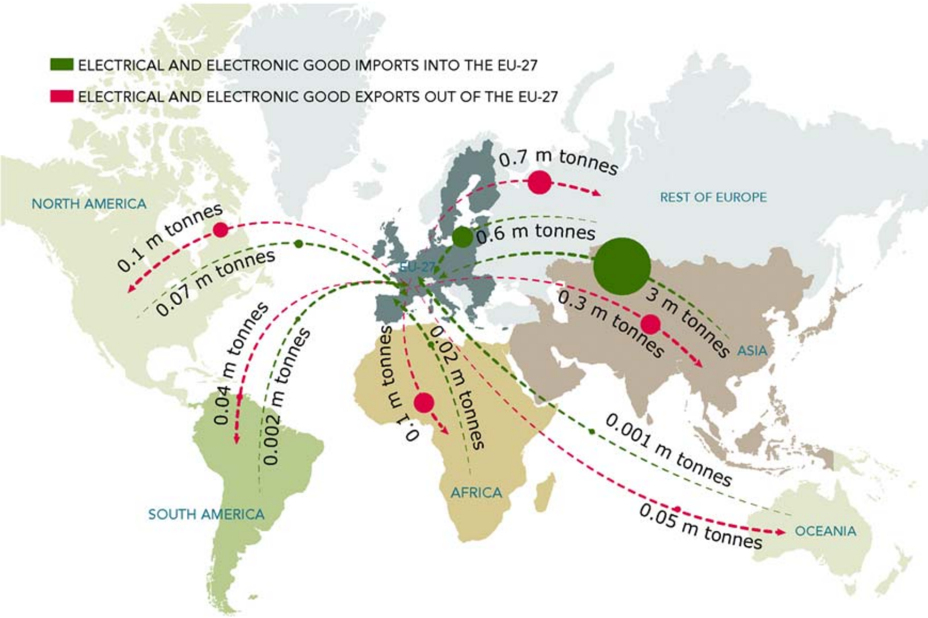

Figure 4.2.1: Imports and exports of EEE

4.2.1.3 Consumption

Contemporary electronic products are icons of modernity and relate to core issues of consumption and identity. Electronic devices such as mobile phones and flat screen TVs function as status symbols for the individual consumer. In connection with this symbolic function, these electronic products are being replaced at an accelerating rate and have increasingly shorter life spans. In developing countries, statistics on the number of telephones and TVs are used as indicators of the state of development. In Western societies, the number of personal computers with broad-band connection and the turnover rate of mobile phones are viewed as indicators of national competitiveness.[35]

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[32] www.step-initiative.org/overview-eu.html
[33] ec.europa.eu/eurostat/web/waste/key-waste-streams/weee
[34] www.eea.europa.eu/data-and-maps/figures/imports-and-exports-of-electrical
[35] Paragraph based on: Lauridsen, E. H. and U. Jørgensen. 2010. *Sustainable transition of electronic products through waste policy*. Research Policy 39: 486–494.

4.2.1.4 Collection & processing

In the mid-1990s, more than 90% of WEEE was landfilled, incinerated, or recovered without pre-treatment and, therefore, a large proportion of hazardous substances found in the municipal waste stream came from WEEE. Already at that time, the amount of WEEE arising as waste was estimated to be around 6 million tonnes in the EU. Nowadays, WEEE is one of the largest growing waste streams globally.[36] Table 4.2.3 shows the evolution of global e-waste volumes. The estimates of the United Nations University (UNU) indicate that in 2014, the 27 member states of the EU produced about 9.5 million tonnes of e-waste. This number is expected to grow[37].

Continent	Region	2009	2010	2011	2012	2013	2014	2015	2016	2017
Africa	Eastern Africa	0,1	0,1	0,2	0,2	0,2	0,2	0,2	0,3	0,3
Africa	Middle Africa	0,1	0,1	0,1	0,1	0,1	0,1	0,2	0,2	0,2
Africa	Northern Africa	0,5	0,6	0,6	0,7	0,8	0,8	0,9	1,0	1,1
Africa	Southern Africa	0,3	0,3	0,3	0,3	0,4	0,4	0,4	0,4	0,4
Africa	Western Africa	0,2	0,2	0,3	0,3	0,3	0,3	0,4	0,4	0,4
Americas	Caribbean	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Americas	Central America	0,9	0,9	1,0	1,0	1,1	1,1	1,2	1,3	1,3
Americas	Northern America	6,8	7,0	7,3	7,5	7,6	7,8	7,9	8,1	8,3
Americas	South America	1,9	2,1	2,2	2,4	2,6	2,7	2,9	3,0	3,2
Asia	Central Asia	0,1	0,1	0,2	0,2	0,2	0,2	0,2	0,3	0,3
Asia	Eastern Asia	6,4	6,9	7,5	8,2	8,9	9,6	10,4	11,2	11,9
Asia	South-Eastern Asia	1,2	1,3	1,4	1,5	1,7	1,8	2,0	2,1	2,2
Asia	Southern Asia	1,7	1,9	2,1	2,3	2,5	2,7	3,0	3,2	3,4
Asia	Western Asia	1,2	1,3	1,3	1,4	1,5	1,6	1,7	1,8	1,9
Europe	Eastern Europe	2,0	2,2	2,3	2,4	2,5	2,7	2,8	2,9	3,0
Europe	Northern Europe	2,1	2,1	2,2	2,3	2,3	2,3	2,4	2,4	2,4
Europe	Southern Europe	2,3	2,4	2,5	2,6	2,6	2,6	2,7	2,7	2,7
Europe	Western Europe	3,8	3,9	4,0	4,1	4,1	4,2	4,2	4,3	4,4
Oceania	Australia and New Zealand	0,5	0,5	0,5	0,5	0,5	0,6	0,6	0,6	0,6
Oceania	Melanesia micronesia and polynesia	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
total		**32,3**	**34,2**	**36,1**	**38,1**	**40,1**	**42,0**	**44,1**	**46,1**	**48,2**

Unit: million metric tonnes = 1 000 000 000 kg

Source: Baldé, C.P., Wang, F., Kuehr, R., Huisman, J. (2015), The global e-waste monitor – 2014, United Nations University, IAS – SCYCLE, Bonn, Germany.

Table 4.2.3: E-waste by country

In recent years, transboundary flows of e-waste have become a major concern. According to a report released by The International Labour Organization (ILO) 80% of the e-waste sent by developed countries for recycling ends up being shipped illegally to developing countries. In those countries informal workers extract valuable components from the waste, most of the times by informal workers using rudimentary techniques. The manual processing of WEEE

[36] Until here paragraph based on: Ylä-Mella, J., K. Poikela, U. Lehtinen, P. Tanskanen, E. Román, R. L. Keiski, and E. Pongrácz. 2014. *Overview of the WEEE Directive and Its Implementation in the Nordic Countries: National Realisations and Best Practices*. Journal of Waste Management Volume 2014: 457372. http://dx.doi.org/10.1155/2014/457372.

[37] McCann, D. and A. Wittmann. 2015. *Solving the E-Waste Problem (Step) Green Paper: E-waste Prevention, Take-back System Design and Policy Approaches*. www.step-initiative.org/files/step-2014/Publications/Green%20and%20White%20Papers/Step%20Green%20Paper_Prevention&Take-backy%20System.pdf.

poses several health risks due the high presence of toxic materials. It is estimated that 70% of electronic waste discarded and exported ended up in China with further exportation to neighbouring countries such as Cambodia and Vietnam. The report highlighted that many of those countries lack:
- adequate regulations to implement the new waste stream;
- effective enforcement of e-waste regulations;
- regulations to ensure the safety of those who deal with the discarded waste; and,
- financial incentives to recycle the waste in an environmental manner.

The developing countries are dealing with the burden of a global problem, without the adequate technology to deal with it. In addition, developing countries are also generating themselves a large amount of e-waste. It is predicted that, by 2020, in both China and South Africa, there will be 200-400 per cent more e-waste from old computers than in 2007, and a staggering 500 per cent more in India. A major problem regarding the facilitation of the trade in e-waste also relates to the absence of regulations to ensure the safety of those who deal with the discarded waste and the lack of financial incentives to recycle the waste in an environmental friendly manner in developing countries.[38]

4.2.2 Market structure of EEE chain

The EEE product chain consists of two barely connected industries (and related markets): on one hand the electronics industry and retailers, and on the other hand the processors of EEE waste.

4.2.2.1 Electronics industry and retail[39]

Electronics manufacturing can be described as network-based mass production, where large-scale manufacturing complexes are combined with specialized companies focusing on product development and marketing. The rapid shifts in technologies and standards are reflected in the industrial structure, with a separation of product lines. Contract manufacturers produce products for the global market, and brand-name firms have few incentives to maintain the manufacture of their products close to their headquarters in industrialized countries (as Figure 4.2.1 already showed). Instead, brand-name firms focus on product development, design and marketing based on supplies by OEMs (Original Equipment Manufacturers supplying companies who add their own brand-names to these) and component producers (Lüthje, 2006).

The ability to define new products for end users is seen as the industry's key competence, including the ability to minimize the time required for putting new products on the market. The increased speed of innovation, especially in high-tech electronics, has created instabilities in the product chain, where rapid new shifts in technologies result in cycles of overproduction and surplus capacities. Manufacturing is not considered important in itself for market control, with the exception of some specific areas such as screens and computer chips.

[38] Paragraph based on: Amorim, I. and V. Pulla. 2014. *Transboundary Trade of Second-hand Electrical and Electronic Equipment (EEE): Framed by the Resilience Concept*. International Journal of Social Work and Human Services Practice 2(6): 319-324. www.academia.edu/9818869/Transboundary_Trade_of_Second-hand_Electrical_and_Electronic_Equipment_EEE_Framed_by_the_Resilience_Concept

[39] Paragraph based on: Lauridsen, E. H. and U. Jørgensen. 2010. *Sustainable transition of electronic products through waste policy*. Research Policy 39: 486–494.

The computer industry is a forerunner in controlling horizontal industrial structures through their ability to define new products by breakthrough technologies or product design. Most products are manufactured through complex chains of suppliers delivering specific components – e.g. computer chips, hard disks, optical devices, flat screens, or sound equipment – which form large industries of their own. Especially the telecommunications industry has developed a modular approach for new products, which has been supported by lean manufacturing and outsourcing initiatives. The widespread use of contract manufacturing is supported by competing and diversified conformity standards for most electronic products and technologies. These are developed through voluntary cooperation between electronics companies. Proprietary standards are important tools for companies to control access to the market, but also play an important role in allowing for downstream manufacturers to develop auxiliary products. One outcome of the highly distributed production of complex products is that there is no clear structure and distribution of agency among the involved producers, even though some major brand-name producers have the lead in innovation and exercise some control over their supplies.

4.2.2.2 Waste of EEE (WEEE) collection and processing market[40]

There are many actors involved in WEEE collection, trading, and recycling. Figure 4.2.2 below shows, through a simplified structure, the main actors and relationships between them. WEEE flows start with consumers/households and businesses: they decide in first instance if WEEE moves into the direction of the national and/or producers' collection system or not. Households can, for example, deliver WEEE at a municipal collection point (or container park) or retail collection point.

By national laws, transposing EU legislation, municipalities are required to provide households at least one location where they can discard WEEE (see section 4.2.4). The producer systems or compliance schemes (i.e. 'national' systems) have contracts in place with municipalities to collect and recycle all WEEE collected. Alternatively, as the UNU 2012 study on Dutch WEEE flows shows, households can also give their WEEE to local scrap processors or door-to-door collectors.[41] In urban areas, WEEE left on the kerbside is most of the time picked up by scrap metal dealers. WEEE is also taken back by installers (e.g. plumbers, or the delivery contractors working for retailers), and often directly sold by them to scrap dealers. Generally, this WEEE ends in ferrous metal shredders along with other ferrous metals. At this point, WEEE becomes unrecognisable as WEEE. UNU calls these alternative options 'complementary WEEE flows' (illustrated by red arrows in Figure 4.2.2) as WEEE is sold to other parties than the official schemes (national or producers' systems). Moreover, small household appliances are sometimes simply thrown away with residual household waste.

Like consumers, businesses also dispose of their WEEE, but through different channels. Business WEEE principally flows via WEEE processors, refurbishers, regional scrap metal processors or goes directly to national recyclers. Typically, almost all of business WEEE

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[40] Paragraph based on: BIO Intelligence Service. 2013. *Equivalent conditions for waste electrical and electronic equipment (WEEE) recycling operations taking place outside the European Union, Final Report prepared for European Commission – DG Environment*. www.ec.europa.eu/environment/waste/weee/pdf/Final%20report_E%20C%20S.pdf.

[41] Huisman, J., M. van der Maesen, R.J.J. Eijsbouts, F. Wang, C.P. Baldé, and C.A. Wielenga. 2012. *The Dutch WEEE Flows*. Bonn, Germany: United Nations University, ISP – SCYCLE. ec.europa.eu/environment/waste/weee/pdf/Report_Dutch_WEEE_Flows%202012%2003%2015.pdf

results in complementary streams. It is important to note that in reality there are many loops between the actors in the chain.

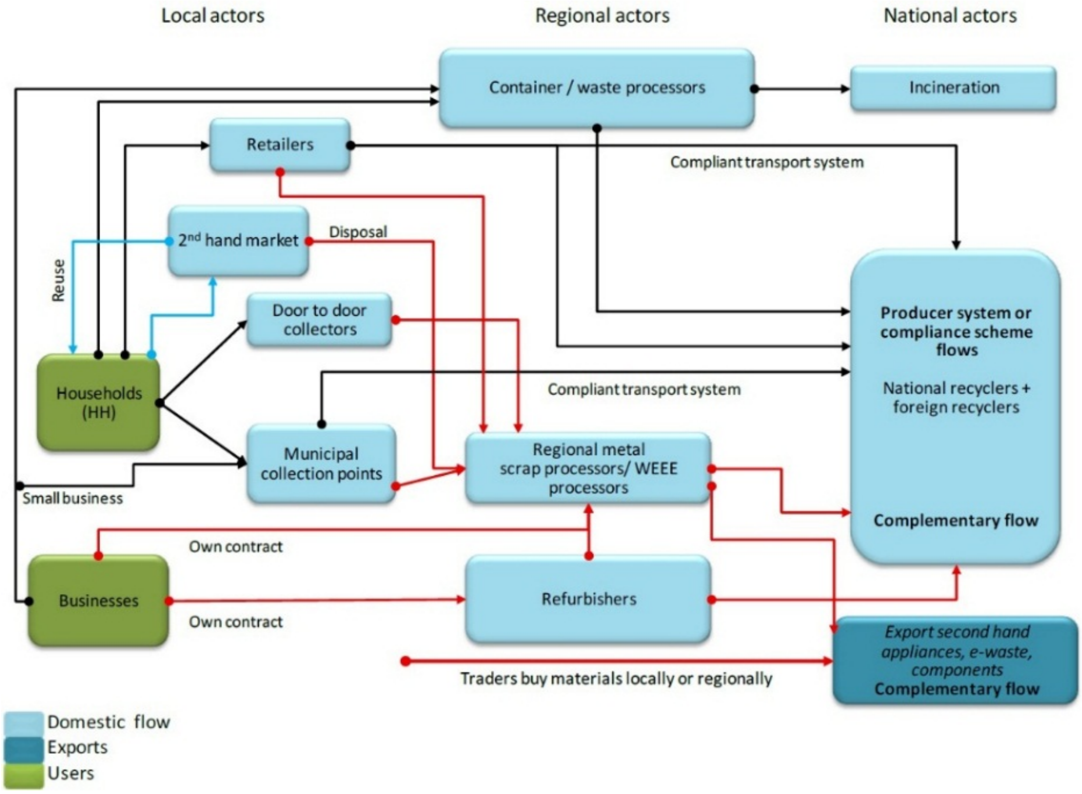

Figure 4.2.2: Typical WEEE Flows in EU member states[42]

4.2.3 Strengths and challenges in the circularity of the EEE product chain

Significant quantities of steel (or other scrap metals such as copper) present in EEE are traditionally already recycled. Nevertheless, without policy instruments, the EEE chain is far from circular, especially with regard to the small quantities of critical speciality materials that are used. European issues in the electronic products chain can be separated in two categories: issues related to the production and consumption and issues related to waste. With regards to EEE production and consumption two major issues can be identified:

1. the intensive use of natural resources for EEE manufacturing is leading to rising and volatile resource prices and to a damaging impact on the environment. Reserves are finite and, for some materials, we may see supply constrained at in the future.[43]
2. the increasing volumes of EEE are problematic. Improved energy performance of individual products is more than counterbalanced by increased consumption.

[42] Taken from: BIO Intelligence Service. 2013. *Equivalent conditions for waste electrical and electronic equipment (WEEE) recycling operations taking place outside the European Union, Final Report prepared for European Commission – DG Environment*.

[43], McCann, D. and A. Wittmann. 2015. *Solving the E-Waste Problem (Step) Green Paper: E-waste Prevention, Take-back System Design and Policy Approaches*. www.step-initiative.org/files/step-2014/Publications/Green%20and%20White%20Papers/Step%20Green%20Paper_Prevention&Take-backy%20System.pdf.

Miniaturisation reduces the amount of materials used in electronics, but also makes it increasingly difficult to extract these tiny amounts for recycling.[44]

The many facets of the WEEE problem stem from three key characteristics of this waste stream:

1. the continued increase in WEEE volumes. Besides, the increasing EEE volumes, electronic products are being replaced at an accelerating rate and have increasingly shorter life spans. Design for longer product-life and ease of repair is in obvious conflict with the existing electronics consumption pattern.
2. WEEE, despite substance bans around the world, continues to contain numerous materials that are considered toxic and have led to increased environmental concern about improper disposal and treatment of these products; and
3. the costs of recycling WEEE can exceed the revenues generated from the recovered materials. These high costs of proper recycling are due either to the complex management required to contain the hazardous materials or because of the difficulty of separating highly commingled materials in complex products, which leads to problems around financing responsible management. This can incentivise the illegal transboundary shipment of WEEE to countries – under the guise of reuse – where they can be recycled at a lower cost, leading to increased profit for the brokers but without the safe management of the hazardous components.

The abovementioned issues can result in WEEE flows being handled without care – causing hazardous fractions to escape into the environment – or WEEE flows being exported to countries where recycling can be profitable, mainly due to cheap labour or the improper treatment of hazardous fractions. In addition, complex combinations of materials coupled with substandard treatment and recycling methods can lead to a loss of key resources locked in the e-waste.

A fundamental weakness, which we will further discuss in 4.2.6, is that there is very little coordination throughout the cycle: production actors are not or very limited engaged in design for recycling and do not coordinate their designs and manufacturing very well with those involved in processing the waste materials.

4.2.4 EU Policy instruments relevant to the circularity of EEE

EEE is intensely and directly addressed by EU policy instruments. The most relevant EU policy frameworks are:

- Raw Materials Initiative / Ad-Hoc Working Group on Defining Critical Raw Material
- Eco-design
- Energy labelling
- RoHS Directive
- REACH
- Waste Directive
- Shipments of waste
- Industrial Emissions Directive (IED) & BAT for Waste Treatment
- WEEE Directive

[44] Paragraph based on: Lauridsen, E. H. and U. Jørgensen. 2010. *Sustainable transition of electronic products through waste policy*. Research Policy 39: 486–494.

Of these frameworks the WEEE Directive is by far the most important measure with respect to the processing of e-waste within the EU and so closing material loops. The WEEE Directive has introduced an End-of-Life (EoL) EEE take-back system in the EU in order to address the abovementioned issues. The WEEE Directive will be further discussed below.

4.2.4.1 Raw Materials Initiative[45]

The EU has agreed on an integrated raw materials strategy. The strategy is based on the following three pillars:

(1) ensure access to raw materials from international markets under the same conditions as other industrial competitors;
(2) set the right framework conditions within the EU in order to foster sustainable supply of raw materials from European sources;
(3) boost overall resource efficiency and promote recycling to reduce the EU's consumption of primary raw materials and decrease the relative import dependence.

Furthermore, the Commission has identified and defined so-called critical raw materials for the EU. A Commission staff working document suggests a high vulnerability of the EU for a number of raw materials. Activities related to the strategy mainly involve policy research, technological R&D, and creating platforms and networks, including building relations with mineral rich regions. As such, they might have a medium to long term, diffuse impact on the EEE product chain, instead of a concrete and immediate effect.

4.2.4.2 Eco-design Directive[46]

The Eco-design Directive provides with consistent EU-wide rules for improving the environmental performance of energy related products (ERPs). It prevents disparate national legislations on the environmental performance of these products from becoming obstacles to the intra-EU trade. This should benefit both businesses and consumers, by enhancing product quality and environmental protection and by facilitating free movement of goods across the EU.

Eco-design regulations require manufacturers to decrease the energy consumption of their products by establishing minimum energy efficiency standards. By setting these standards at European level, manufacturers do not have to navigate through multiple national regulations when launching their products on the market. The Eco-design requirements for individual product groups are created under the EU's Eco-design Directive, a process managed by the European Commission. As an alternative, industry sectors may also sign voluntary agreements to reduce the energy consumption of their products. The Commission formally recognises such agreements and monitors their implementation.

4.2.4.3 Energy Labelling Directive[47]

The Energy Labelling Directive establishes a legal framework for the European Commission to set mandatory energy labelling requirements for energy-related products (except vehicles) placed on the EU market (regardless of their origin). Energy labels allow consumers to make informed choices by being alerted on the consumption/running cost of a product before they make their purchasing decision. The label does however not address energy costs in other phases of the product life cycle (which are more relevant for circularity).

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[45] Section based on: European Commission. 2008. *The raw materials initiative — meeting our critical needs for growth and jobs in Europe*. eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0699:FIN:en:PDF
[46] Section based on: http://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficient-products
[47] Section based on: http://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficient-products

4.2.4.4 Restriction of Hazardous Substances Directive (RoHS) Directive[48]

The RoHS Directive restricts the use of six hazardous materials in the manufacture of various types of electronic and electrical equipment. It is closely linked with the WEEE Directive which sets collection, recycling and recovery targets for electrical goods and is part of a legislative initiative to solve the problem of huge amounts of toxic e-waste.

4.2.4.5 Registration, Evaluation, Authorisation and restriction of Chemicals Directive (REACH)[49]

REACH is a lengthy and complex EU Regulation which seeks to protect human health and the environment while also supporting competition within the chemicals industry. The REACH Regulation brings about regularisation of the chemicals industry and therefore also the EEE industry. REACH places responsibility on the manufacturer/producer for ensuring that any chemicals they put on the market are properly assessed and managed in terms of their risks.

4.2.4.6 Waste Framework Directive (2008/98/EC)50

The Waste Framework Directive (WFD) of 2008 (2008/98/EC) sets the basic concepts and definitions related to waste management such as definitions of waste, recycling, and recovery. It thus provides a general framework of waste management requirements and sets the basic waste management definitions for the EU. Along with the waste management definitions, the WFD applies a waste management hierarchy as follows: prevention, preparing for re-use, recycling, recovery and disposal. Further, it establishes a legal framework for the treatment of waste, where waste treatment facilities must obtain permits and registrations to operate (Article 23). Further, the WFD includes requirements regarding the control of hazardous waste (Art. 17), mixing ban (Art. 18), labelling (Art. 19) and record keeping of hazardous waste (Art. 21). For EEE the Waste Framework Directive mainly provides guiding principles on an abstract level, which are translated into concrete policy measures in other EU policy instruments, such as WEEE (see further). Indirectly certain EEE waste flows are subject to general waste targets (e.g. reducing municipal waste).

4.2.4.7 The Waste Shipment Regulation[51]

The WSR adopted by the EU in 2006 sets out legal procedures and control regimes for the shipment of waste to 'harmonise' two international agreements, the Basel Convention and the OECD Decision. It is a legally binding legislation, with its waste categories derived from the two international agreements. The WSR prohibits the export of waste for disposal and export of dangerous wastes to non-OECD countries. The export of 'Green Waste' is permitted though, as long as the importing country allows it, or allows it with specific controls (Article 37 of the WSR). Within the 'Green' list of waste are categories of WEEE that are considered to be non-hazardous. China completely bans the importation of electronic scrap, despite it being considered a "Green" Listed Waste in the WSR.

[48] Taken from: BIO Intelligence Service. 2013. *Equivalent conditions for waste electrical and electronic equipment (WEEE) recycling operations taking place outside the European Union, Final Report prepared for European Commission – DG Environment*.

[49] Goodship, V. (Editor) and A. Stevels (Editor). 2012. *Waste Electrical and Electronic Equipment (WEEE) Handbook*. Sawston, UK: Woodhead Publishing.

[51] Taken from: BIO Intelligence Service. 2013. *Equivalent conditions for waste electrical and electronic equipment (WEEE) recycling operations taking place outside the European Union, Final Report prepared for European Commission – DG Environment*.

4.2.4.8 *The Industrial Emissions Directive (IED) / BAT for Waste Treatment*[52]

In order to take further steps to reduce emissions from industrial production processes, the Commission adopted the Industrial Emissions Directive (IED). Its aim is to achieve significant benefits to the environment and human health by reducing harmful industrial emissions across the EU, in particular through better application of Best Available Techniques. Operators of industrial installations operating activities covered by Annex I of the IED are required to obtain an integrated permit from the authorities in the EU countries. Although EEE production itself is not directly targeted by the IED, waste management and many industries supplying for EEE production, such metals and chemicals, are explicitly regulated.

The IED expressly provides that Best Available Techniques (BAT) conclusions shall be the reference for setting the permit conditions. BAT may be defined for the treatment of WEEE in accordance with the IED, as contemplated by the WEEE Directive.

4.2.4.9 *WEEE Directive*

The objective of the WEEE Directive is to promote reuse, recycling and other forms of recovery of WEEE to a) reduce the quantity of such waste to be disposed and b) to improve the environmental performance of the economic operators involved in its treatment. The WEEE Directive sets criteria and targets for the collection, treatment and recovery of WEEE (Table 4.2.2.4 shows the minimum targets). Moreover, a rate of separate collection of at least 4 kg/inhab./year of WEEE from private households, or the same amount of WEEE that was collected in the three preceding years, whichever is greater, has to be collected.[53]

The minimum targets of recovery, reuse, and recycling rates in the WEEE Directive 2012/19/EU

	Category	Recovery/reuse and recycling targets [%] in period 1*	Recovery/reuse and recycling targets [%] in period 2**	Recovery/reuse and recycling targets [%] in period 3***
1	Large household appliances	80/75	85/80	
2	Small household appliances	70/50	75/55	
3	IT and telecommunications equipment	75/65	80/70	
4	Consumer equipment	75/65	80/70	
5a	Lighting equipment	70/50	75/55	
5b	Gas discharge lamps	—/80	—/80	
6	Electrical and electronic tools	70/50	75/55	
7	Toys, leisure, and sports equipment	70/50	75/55	
8	Medical devices	70/50	75/55	
9	Monitoring and control instruments	70/50	75/55	
10	Automatic disperser	80/75	85/80	
1	Temperature exchange equipment (e.g. refrigerators and heat pumps)			85/80
2	Screens and monitors (e.g. televisions, LCD, and photo frames)			80/70
3	Lamps (e.g. fluorescent lamps and LEDs)			—/80
4	Large equipment (e.g. washing machines and photovoltaic panel)			85/80
5	Small equipment (e.g. vacuum cleaners, smoke detectors, and sport equipment)			75/55
6	Small IT and telecommunication equipment (e.g. mobile phones, GPS, and personal computers)			75/55

*Period 1: from August 13, 2012 until August 14, 2015.
**Period 2: from August 15, 2015 until August 14, 2018.
***Period 3: from August 15, 2018 onwards.

Table 4.2.2.4: Targets for re-use and recovery[54]

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[52] Based on: http://ec.europa.eu/environment/industry/stationary/ied/legislation.htm

[53] Paragraph based on: Ylä-Mella, J., K. Poikela, U. Lehtinen, P. Tanskanen, E. Román, R. L. Keiski, and E. Pongrácz. 2014. *Overview of the WEEE Directive and Its Implementation in the Nordic Countries: National Realisations and Best Practices*. Journal of Waste Management Volume 2014: 457372. http://dx.doi.org/10.1155/2014/457372.

[54] From: Ylä-Mella, J., K. Poikela, U. Lehtinen, P. Tanskanen, E. Román, R. L. Keiski, and E. Pongrácz. 2014. *Overview of the WEEE Directive and Its Implementation in the Nordic Countries: National Realisations and Best Practices*. Journal of Waste Management Volume 2014: 457372. http://dx.doi.org/10.1155/2014/457372.

WEEE that is treated within the EU must be done so at a treatment facility that has been approved by the relevant member state authority. WEEE that is exported out of the Union must comply with the WSR. The WEEE exported out of the EU will count towards the fulfilment of recycling/recovery targets only if the exporter can prove that the treatment took place in conditions that are equivalent to the requirements of the Directive.[55]

The first WEEE Directive (2002/96/EC) was adopted on 27 January 2003 and has since been revised. The new WEEE Directive 2012/19/EU has assigned producers the responsibility for the financing and collection of EoL electronics. EPR for the waste management phase of EEE was regulated in order to create an economic incentive for producers to move towards more environmentally sound design and manufacturing. Therefore, the establishment of the WEEE Directive aimed at encouraging producers to consider the design and production of EEE in relation to EoL management, an approach that takes into account and facilitates their repair, possible upgrading, reuse, disassembly and recycling, and, finally, the best methods of recovery and disposal.[56]

4.2.5 EEE Policy strengths, weaknesses and opportunities

The EEE policy instruments have been important in establishing a hitherto virtually non-existent electronics recycling industry. However the major challenge for the middle term remains to channel WEEE into these formal, regulated channels for recycling. Probably the majority of all EEE remains outside the formal recycling process (although performance varies hugely between member states). This implies the ecological problems the policies where designed to address, are only mitigated to a limited extent. Another challenge remains that some of the critical trace elements are very difficult to impossible to recover, but such materials are increasingly considered to be vital for the robustness of the European economy.

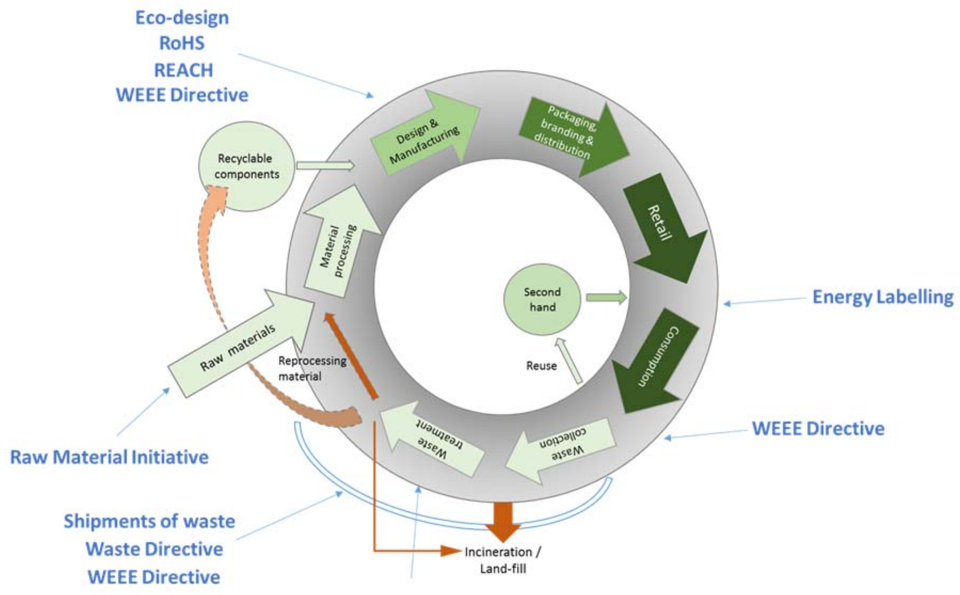

Figure 4.2.3: Policy instruments in the WEEE cycle

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[55], Paragraph based on: BIO Intelligence Service. 2013. *Equivalent conditions for waste electrical and electronic equipment (WEEE) recycling operations taking place outside the European Union, Final Report prepared for European Commission – DG Environment*.

4.2.5.1 Limited reach WEEE Directive & UEEE exports

Figure 4.2.2.3 below maps some of the routes of used EEE and WEEE flows in Europe. On the right hand side are the producer systems (take-back systems), which collect from municipalities and retailers. According to media reports, this channel is collecting approximately one-third of WEEE arising. The flows on the left hand are collected in parallel to producer flows and are not reported nor measured by statistics. Estimates from several recent studies indicate that around 40% of WEEE is collected and recycled by this sector.[57]

Figure 4.2.2.3 shows that part of the WEEE arising from end-users goes into unsorted municipal waste (around 10%). Furthermore about 15% of UEEE is exported, mainly for re-use. It is important to note that part of this UEEE either becomes WEEE during the transport (e.g. if there is not appropriate protection of the product during the transport) or a short period of time after arriving in the destination country. Although re-usable second hand EEE exports are legal, exports of WEEE are not under international legislation. For instance, China signed the Basel Convention and was one of the first global proponents of a total ban on the hazardous waste trade. However, the number of continuous shipments to China has not ceased with those agreements, an indication that the issue not only concerns the lack of laws, but also the unsuccessful enforcement of the law.[58]

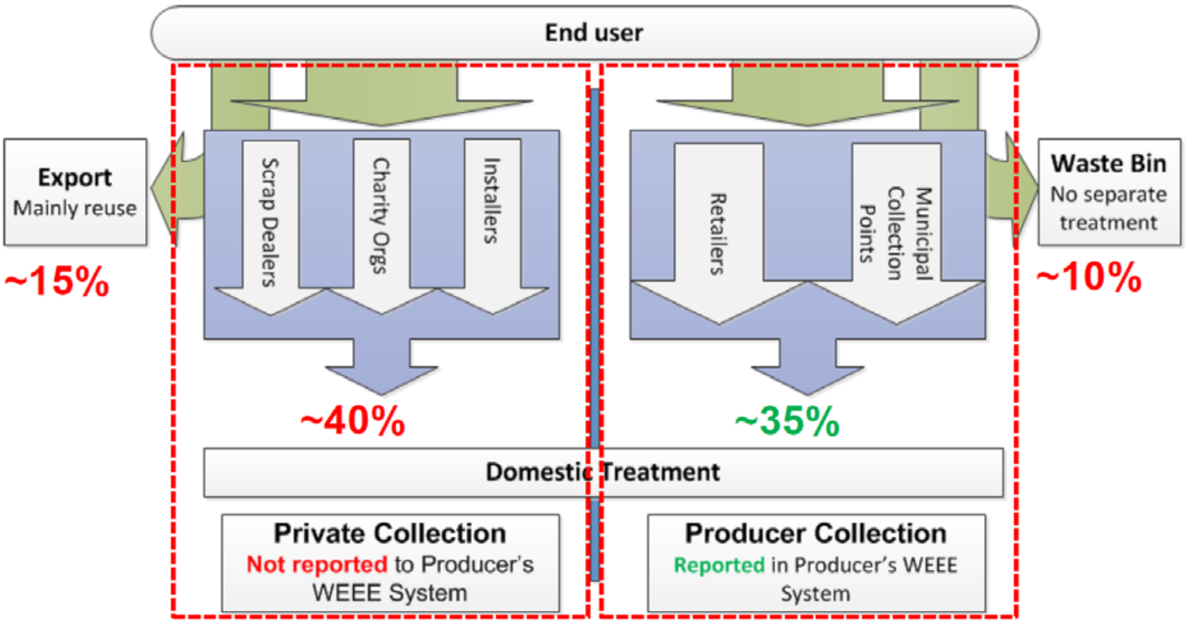


Figure 4.2.2.3: Only one-third of the WEEE collection is reported in the EU[59]

4.2.5.2 Design for recycle is not stimulated

The principle of EPR within the WEEE Directive has not managed to sufficiently encourage design for recycle. The incentive for manufacturers is not strong enough. Under an EPR

[57] Paragraph based on: BIO Intelligence Service. 2013. *Equivalent conditions for waste electrical and electronic equipment (WEEE) recycling operations taking place outside the European Union, Final Report prepared for European Commission – DG Environment*.

[58] Paragraph based on: Amorim, I. and V. Pulla. 2014. *Transboundary Trade of Second-hand Electrical and Electronic Equipment (EEE): Framed by the Resilience Concept*. International Journal of Social Work and Human Services Practice 2(6): 319-324. www.academia.edu/9818869/Transboundary_Trade_of_Second-hand_Electrical_and_Electronic_Equipment_EEE_Framed_by_the_Resilience_Concept

[59] From: BIO Intelligence Service. 2013. *Equivalent conditions for waste electrical and electronic equipment (WEEE) recycling operations taking place outside the European Union, Final Report prepared for European Commission – DG Environment*.

regime, responsibility can be assigned either individually, where producers are responsible for their own products, or collectively, where producers in the same product type or category fulfil the responsibility for EoL management together. It is important to note that the benefits of design incentives are best achieved, all things being equal, through a system that is as close to Individual Producer Responsibility (IPR) as possible, because a producer will be most inclined to improve design when he is able to reap the benefits of the improvements. In a collective solution, if a producer improves the design of a product which leads to lower recycling cost or improved material recovery, then all producers in this product category will also reap the rewards of the improvement made by this one producer. In the end, therefore, a collective solution would lead to progressive producers subsidising producers who failed to make any effort to improve their products. IPR is, however, a more complicated system to administer, and examples of functioning IPR models are lacking. It is therefore advisable for countries developing new systems and policies to focus on collective EPR solutions before starting to individual organization solutions.[60]

Also, the focus of design for recycle should not only be on less toxic, easily repairable and recyclable products on the market, but also on extension of product lifetime. Current legislation has failed to address this issue. The electronics regime shows rather contradictory tendencies within an existing structure of production and consumption that seems quite stable and resistant to change. It can be argued that innovation and rapid improvements may lead to improved sustainability, but shorter lifetime and lower costs demonstrate dominant impacts of rebound effects. In general, improvements are converted into consumption growth and carelessness concerning efficiency, although in some instances individual products demonstrate improvements in both resource and energy consumption. Despite these conflicting issues, the electronics regime remains remarkably resistant to the core features of a more sustainable and less resource-depleting regime, such as improved standardization and longer product-lifetime.[61]

4.2.5.3 Promoting responsible consumption

In addition to the efficient management of WEEE recovery systems, the level of consumers' understanding of the importance of separate WEEE collection and their behaviour regarding the return of EOL devices to collection points influences significantly the effectiveness of WEEE recovery.

The Swedish and Norwegian experiences with long history of WEEE recovery prove that raising consumer awareness leads to environmentally sound behaviour and improved WEEE recovery efficiency (see Figure 4.2.2.4).[62]

[60] Paragraph based on: McCann, D. and A. Wittmann. 2015. *Solving the E-Waste Problem (Step) Green Paper: E-waste Prevention, Take-back System Design and Policy Approaches*. www.step-initiative.org/files/step-2014/Publications/Green%20and%20White%20Papers/Step%20Green%20Paper_Prevention&Take-backy%20System.pdf.

[61] Paragraph based on: Lauridsen, E. H. and U. Jørgensen. 2010. *Sustainable transition of electronic products through waste policy*. Research Policy 39: 486–494.

[62] Paragraph based on: Ylä-Mella, J., K. Poikela, U. Lehtinen, P. Tanskanen, E. Román, R. L. Keiski, and E. Pongrácz. 2014. *Overview of the WEEE Directive and Its Implementation in the Nordic Countries: National Realisations and Best Practices*. Journal of Waste Management Volume 2014: 457372. http://dx.doi.org/10.1155/2014/457372.

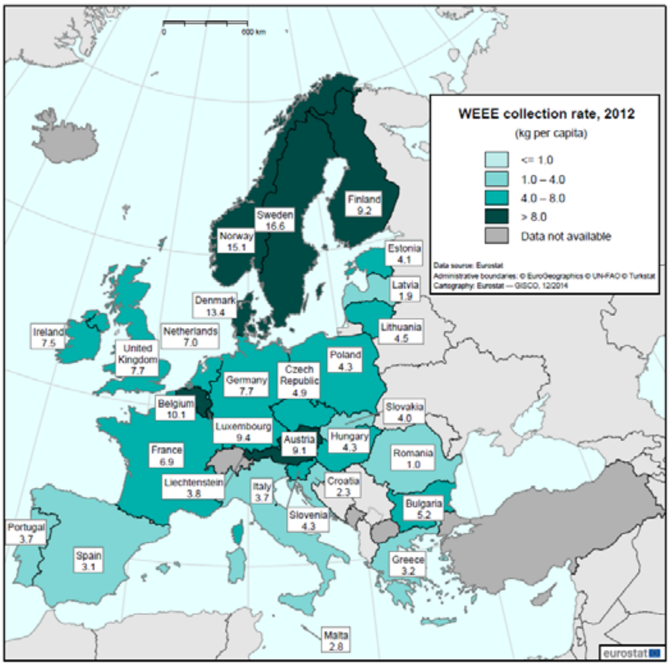


Figure 4.2.2.4: WEEE collection rates[63]

4.2.6 *Long term policy considerations*

As discussed, we can also reflect upon product's chain circularity from a more long-term, radical innovation or transition perspective: what is needed and what are the barriers to become truly a circular product chain consistent with the ideal of a Circular Economy.

From such a perspective, the separated worlds of production and recycling is the major challenge to achieve a largely circular electronics with respect to materials. The present policy mix echoes this watershed: policy concentrates on either raw materials or on collection and recycling of WEEE. Policy instruments aimed at the design phase are mostly concerned with energy use, not with design for recycling, for example by facilitating separation of materials. As a first step, the EU could broaden Ecodesign & -labelling regulations to EEE categories for which Ecodesign criteria (repairability, material selection, etc.) have not been defined.

The WEEE Directive does attempt to interconnect two previously independent regimes: the EEE regime and the waste regime. It does not, however, support and interconnect technological experiments. The WEEE Directive is a top-down policy: it does not support emerging bottom-up dynamics.

If these two worlds are able to meet and fruitfully interact, much more radical system innovations can be expected. This would require radical experiments that cut across the product cycle and combine technological and social innovation: the EU could, for example, support bottom-up initiatives for new ways of consuming EEE through sharing & leasing. Also, the EU should support instruments that facilitate information exchange between manufacturers and recyclers, such as the building of innovation networks in which perspectives from all links in the cycle are present. Last but not least, we recommend the implementation of measures to allow for improved identification of illegal waste shipments.

[63] http://ec.europa.eu/eurostat/web/waste/key-waste-streams/weee

4.3 Case of (polyester) textiles

Textiles are a broad category of materials, both with regard to nature and origin of the material and application (e.g. clothing, household textiles, technical textiles, cleaning and insulation/padding textiles). In this case study, we will interpret ‘textiles’ close to the colloquial use of the term to refer primarily to clothing and secondarily to household items such as curtains, bedlinen, bathroom textile, etc.

We will further focus upon synthetic fibres, and more specifically polyester, for two reasons. First and foremost, other major fibres such as cellulose (viscose), wool and cotton are already biobased and thus in principle a circular material. Notwithstanding environmental issues such as water and land usage, they are thus not a primary interest for the transition to a circular economy, whereas polyester is a petroleum based product and thus of primary interest. Second, polyester is the most used material in clothing and its use is still increasing. On a global scale, the nearly 60 megaton of polyester even represents two-thirds of all fibre production (CIRFS, key statistics, 2013). In the next ten years the market is expected to nearly double (TecNon OrbiChem 2013). Technically, PET plastics are a subcategory of polyesters. In colloquial use, ‘polyester’ and ‘PET’ refer to the same material, but the term ‘PET’ is used for packaging and technical applications, and polyester is the term used in the textile industry and by consumers.

Figure 4.3.1: Composition of apparel consumption (source; FAO 2013)

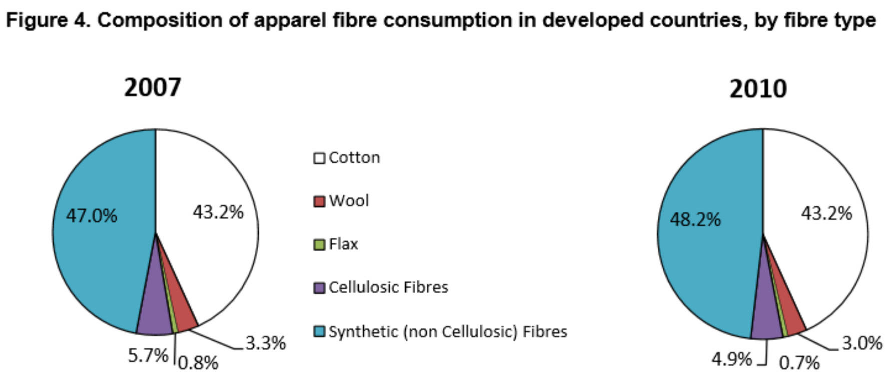
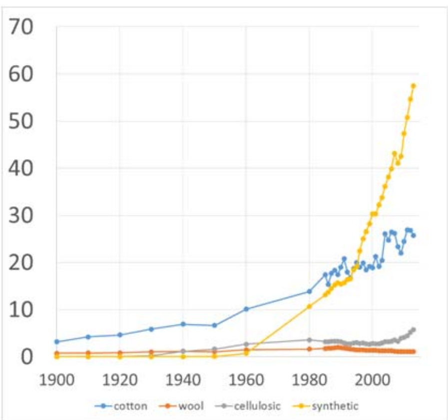


Figure 4.3.2: Global fibre consumption (in megatons) (source:CIRFS)



4.3.1 Materials flows in the polyester textile chain

Polyester fabric is created from fossil crude oil in a number of steps. Crude oil is first refined and reformed, resulting amongst many other organic compounds in the aromatic compound of xylene. Xylene is further processed into terephthalic acid (TA), which when mixed with ethylene glycol[64] (which is derived via a different pathway from petroleum, or alternatively from bio-ethanol) can be used to produce PET plastic. PET plastic can be used for packaging materials, polyester fabric and many other applications (each with slightly different requirements). PEF is a completely biobased alternative to PET, in which the TA has been substituted for furane (a compound in agricultural products and residues)[65].
Another major source of PET for textile polyester, are the recyclates from packaging PET. For example a soda bottle may be recycled by remelting. This is currently the largest application of recovered plastic from bottles, although bottle-to-bottle recycling is becoming more common.

PET for use in textiles is drawn (lengthened) and spun into fibres, and typically woven into fabrics, which are used in the clothing (and wider textile) industry to make the physical final product. Subsequently these products are distributed to retail shops (and increasingly online shops). Depending on the type of product, more economic value might be added in the design, marketing and retail of the product, than in the physical production of the product. After sales and use by the consumer, textile products can take various routes in their life cycle. Most textile items are simply discarded into the general municipal waste and incinerated or land-filled.

However, a flourishing market exists for used clothing, through various ways. First, clothing might be given away (or sold) from consumer to consumer. Second, clothing might directly be sold or given away to second-hand shops by consumers. Third, charities, businesses and municipalities collect used clothing, either by kerbside pickup or by collection containers. This textile ‘waste’ is sorted out and a significant amount of clothing is sold for reuse, often to lower income countries. The profits thus generated are generally sufficient to cover costs of collecting and sorting and even create a profit (or donation to charity). The value of ‘non-wearables’ sorted items is much lower, typically processed for less demanding applications such as padding, insulation and cleaning applications, but in combination with the second-hand sales, still a commercially viable route.

Other recycling routes are not (yet) commercially viable. In principle, textile polyester can also be recycled into new material for clothing and similar applications, typically by reprocessing the polyester into PET recyclate. At the moment this is not done at a significant scale; most likely owing to the non-proven nature of the technology, prohibitive costs and a cheap, policy-driven supply from packaging rPET (see further). This also requires innovation in the sorting process: the sorting of collected textiles is now done manually and focused on sorting out the ‘wearables’ into different market segments. Sorting for material recycling requires material recognition, for example by infrared spectrum scanners. Moreover many polyester fabric are blends, for example cotton-polyester blends, further complicating material reprocessing[66].

Complete substitution of polyester for a biobased material is also a possibility, the mentioned PEF is such an example (although very close in characteristics to PET), but clothing could

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[64] Ethylene glycol constitutes a minority fraction in PET with a molar mass of about 60 grammes, versus TA with a molar mass of about 200 grammes,
[65] http://avantium.com/news/2013-2/First-100-biobased-T-shirts-from-recycled-PEF-bottles.html
[66] http://www.deakin.edu.au/affric/news/2014/06/30/process-takes-textile-recycling-to-new-level

also be more made out of vegetable fibres, such as wool, cotton, flax, hemp, etc. This would be a break with the current trend of substituting natural materials for polyester.
The flow through this cycle is impressive: over 15 kg per capita of man-made fibres, most of which is polyester, or 7,5 million tonnes for the whole EU[67].

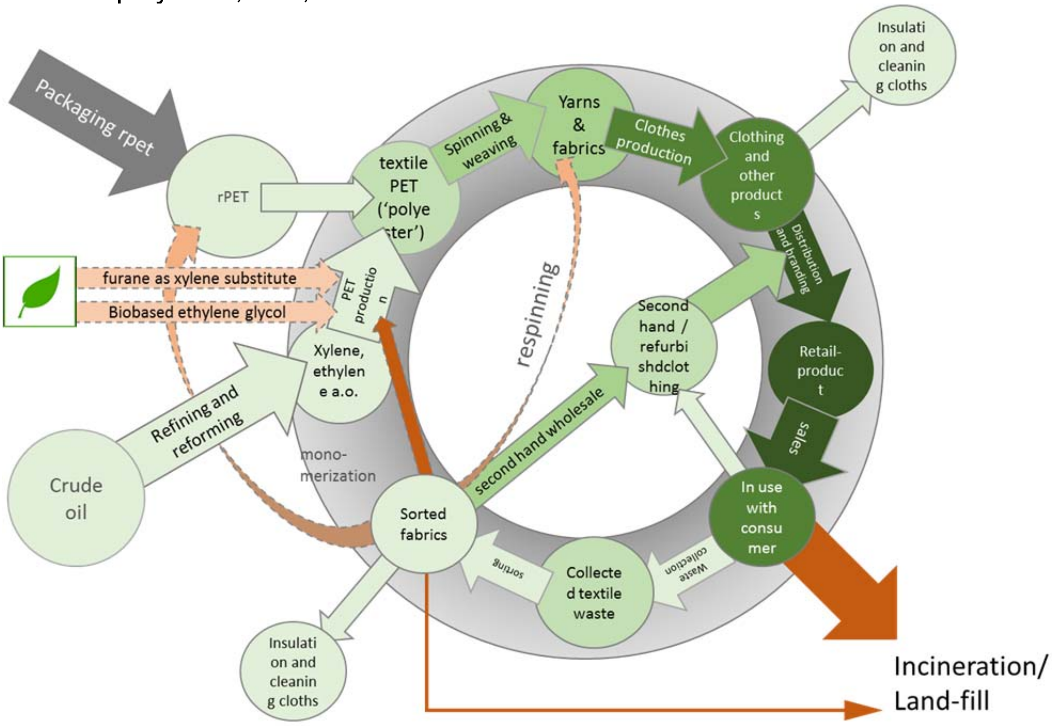

Figure 4.3.3: simplified schematic overview of materials flows in polyester textiles (red: negative value or non-competitive price, ethyl-glycol production not shown)

4.3.2 Market structures

Although the demarcations between industries are not clear-cut, a circular polyester cycle crosses through many different industries and sectors.

4.3.2.1 Chemical industry

Petrochemistry (in Europe represented by EPCA) takes care of the first step in creating synthetic clothing by distilling and cracking crude oil into naphtha and producing the basic chemicals. This industry is dominated by large global players, amongst which some of the world's largest firms, they are structured by vertical integration or core-periphery ecosystems. The basic ingredients for polyester are only one of many, many chemicals produced and refineries also (and primarily) produce fuels. The organisational and economic link between petrochemistry and the textile industry is weak. The EU has traditional a strong global position in petrochemistry, but its competitive position is weakening, amongst others by low energy costs in the US and a tendency to process crude oil closer to the source.
Polymer industry, including recycling and biobased alternatives (represented by Plastics Europe): typically further processing from basic chemicals into polymers is seen as a different subindustry of bulk chemicals. For the plastics industry, polyester fibres are a significant market. A plant producing PET might even produce exclusively for (or integrated with) a polyester fibre plant. Still, PET granulate and PET fibres are a bulk chemical, whose specifications are only slightly modified for different applications and it is typically traded on markets, thus again the economic and organisational links to clothing products are limited.

[67] http://www.textileworld.com/Issues/2015/_2014/Fiber_World/Man-Made_Fibers_Continue_To_Grow

The recycling of PET and production of virgin PET are not typically integrated in the same plant, and are even to some extent different industries. EU has a strong position in plastics production[68] and even though specifically for PET the EU is a net importer[69], the EU has a significant virgin and recycled PET industry.

4.3.2.2 Textile industry

Yarn, weaving, finishing (textile industry proper) is a line of business that constitutes the linking pin between chemical industry that produce materials and the clothing and fashion industry and retail that produce and sell products. It accepts polyester as bulk input, but its output varies from bulk fabrics (e.g. a generic cotton-polyester blend) to fabrics with specific requirements. It is thus moderately linked to textile final products. This is also an industry with relatively large scale international and national players. Traditionally, Europe has a strong position in man-made fibres, but especially for polyester, EU production is stagnating or in decline[70], whilst China is dominating the global market (TecNon OrbiChem 2013).

In contrast to the material production, **clothing production** is characterised by a highly fragmented landscape of small and medium sized companies, whose production for the EU market is often done as contractors for the Western fashion industry (see next). Clothing production is still present in the EU, but most production for EU-markets is situated in low-wage countries outside the EU.

After (and in design and contracting before) production, the business of fashion design, marketing and retail comes into play. In contrast to the previous industries, this industry consists not only low margin products, but also features high-margin, marketing driven products. The nature of retail is rapidly changing, with the fast rise of online shopping and ever shorter times from design to manufacturing to being retired (purportedly, some integrated firms can now go from design to final product in two weeks). A specific niche in fashion retail are second-hand and vintage shops.

4.3.2.3 Textile waste collection and processing

Textile waste collectors and processors takes, as a specialised line of business within the waste industry, take care of collecting, sorting and selling used textiles. This appears to be a market that is relatively small scale in scale of operation and firm size. In the EU, textile waste collectors are often connected to charity. In some cases, charities play a vital role in collection, in other cases firms donate some of their earning to charity.

4.3.3 Strengths and (future) challenges of the product chain

We observe limited coordination or integration if we consider the full (potentially circular) product chain. Individual links in the chain are largely separate industries, only connected to trading intermediate materials and products on a global market. In the first links of the chain, large (petro)chemical firms hold some power, but they operate in a highly competitive, low-margin environment. Considerably more power is consolidated in large fashion and retail firms, whose choices might have a significant influence on the whole chain. Still, at the moment these firms do not seem to exert much power beyond the links in the chain they are

[68] Plastics Europe, the facts, 2014.
[69] http://mcgroup.co.uk/news/20140117/global-pet-supply-exceed-2439-mln-tonnes-2015.html
[70] http://www.cirfs.org/Portals/0/Docs/Shanghai%20November%208-9%202012%20Presentation1%20by%20F%20%20VAN%20HOUTE.pdf

directly involved in, although these firms are facing pressures over extending their control to ensure socially responsible practices with suppliers.

The current polyester textile economy is one that has already some features of a circular economy without a strong (EU) policy presence (see further), demonstrating the circular economy also develops autonomously. One of the strengths of current recycling is its basis in positive business cases for most (if not all) parties involved. Another strength is product re-use, which is in the EU-waste hierarchy to be preferred to material recycling. As most of the ecological footprint of textile polyesters is generated in the phase between base material (polyester fibres) and finished product (see figure), re-use is to be preferred above material recycling.

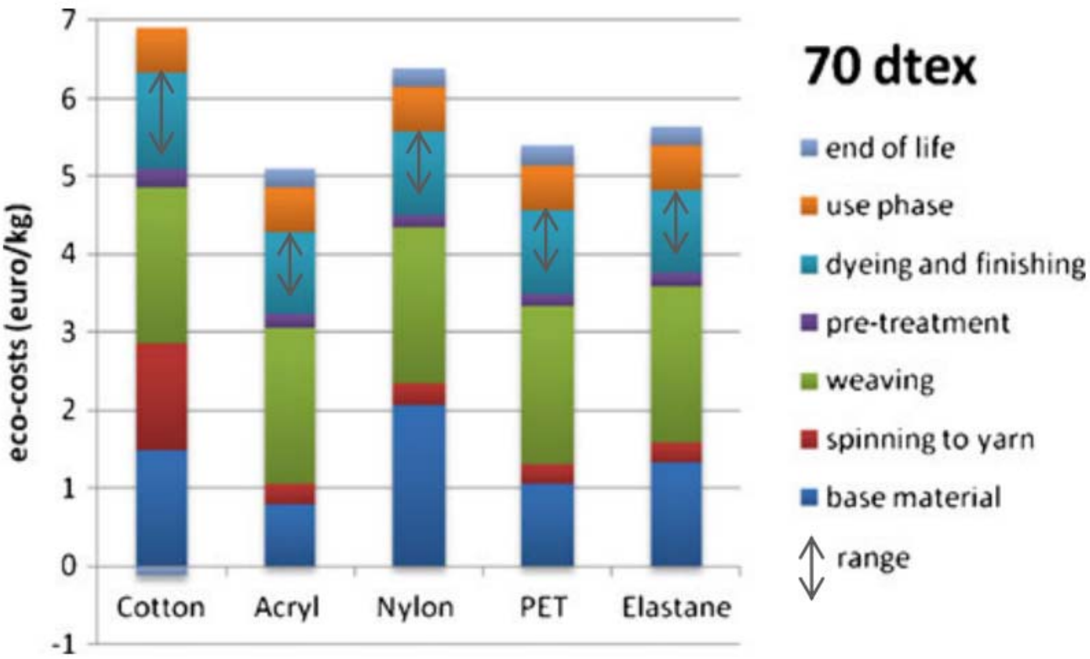

Figure 4.3.4: Ecocosts of different fibre.
Figure taken from: van der Velden, Natascha M., Martin K. Patel, and Joost G. Vogtländer. "LCA benchmarking study on textiles made of cotton, polyester, nylon, acryl, or elastane." The International Journal of Life Cycle Assessment 19.2 (2014): 331-356.

Polyester can also be a good example of value creation through slowly ‘cascading’ down in material quality (instead of rapid downcycling in quality). In ‘cascades’ of material use, virgin materials are first used for the technically and aesthetically most demanding applications and each time recycled for a less demanding use[71].

Theoretically, polyester is a perfect example of such a process. Virgin material can be used for packaging (which can be demanding, especially in aesthetics as typical applications are transparent to show the product), subsequently recycled into fibre for clothing, lastly used in

[71] Although this might appear to be ‘downcycling’, the MacArthur report on Circulary Economy (MacArthur Foundatioin 2012) takes a more nuanced view. If in each cycle economic value is generated and each quality is only gradually degenerated, it could be considered a form of circular economy.

low quality applications such as cleaning cloths or insulation and finally some of the energy can be recovered by burning. The practice is however different. Much of the virgin PET/polyester material in the EU are only used a single time and then incinerated, or worse, landfilled. In each cascade, losses are high. Recently, bottle-to-bottle recycling has increased. At some point, this might limit the availability of high grade rPET from bottles as input for textile polyester. If the circular economy as a whole moves forward, the current circular model for polyester might thus not hold.

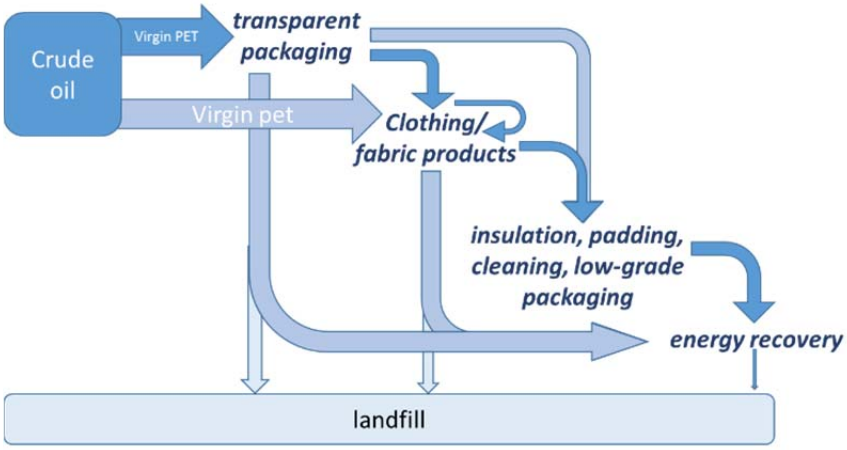

Figure 4.3.5: simplified schematic of cascading use of PET/polyester and 'short-cuts'

Steady but small improvements appear to be made in textile collection and processing and some R&D into new technologies is taking place (see next section). However, it can be doubted if these small advances can off-set some trends towards a more linear economy:

- The overall share of synthetics in textiles is still increasing over natural, biobased materials, thus moving away from a circular economy (as the vast majority of synthetic textiles are fossil based).
- The first life cycle of many textile products appears to be shortening. Clothing has become cheaper, and is easily discarded, moving towards a fully disposable product. This provides opportunities for re-use through the second-hand market, but many pieces of clothing are not re-usable or never enter textile collection systems.

Looking at the organisation of the chain, textile re-use and recycling focal point is firmly in the second half of the cycle: textiles are not specifically designed for recycling and those involved in producing and retailing clothing are not are barely involved in closing the loop. As we concluded earlier, the fashion (retail) industry might have some power in the whole chain to bring about changes, whereas power of parties in other links of the chains are very limited for chain-wide changes.

4.3.4 EU policies

Currently, textile re-use or recycling is not specifically targeted by EU policies. However limited effects could be expected from general waste policies, which we will discuss.

4.3.4.1 Tariffs

As most clothing and other textiles are imported (typically as products, sometimes as yarn or fabric), trade tariffs might have an effect on material use and recycling. However in practice, many major producing countries of clothing for the European market have highly reduced or zero tariffs for textiles. Also, there is no or little differentiation on materials (EU TARIC database). The import of used clothing is also subject to a tariff, although this is not a typical scenario used clothing is typically exported out of the EU. Thus although theoretically tariffs could adversely affect an international circular flow of polyester textiles, the actual effect might be very limited.

4.3.4.2 Carbon pricing and other policies

In theory, there is an incentive to reduce CO2 emissions by recycling, as some CO2 emissions are priced through the Emission Trading System, most notably emissions owing to the use of process energy in the petrochemical industry to produce PET and its precursors. However, regardless of discussions about the strength of the EU-ETS in general, PET is an energy intensive but also value intensive product. The price of PET is a couple orders of magnitude higher than the price of the required CO2 rights. Moreover, the textile industry also sources polyester from non-EU sources.

4.3.4.3 Waste directive

The EU Waste directive sets aims for recycling percentages, amongst which a 50% re-use and recycling of household waste. Although textiles are typically a small fraction (typically a few percent72) of household waste, this might give a small incentive to member states to stimulate textile collection schemes. Also, textiles might become part of wider collection efforts for other materials.

4.3.4.4 Labelling requirements and ecological labels

Clothing (and other textiles) in the EU are subject to labelling requirements (see 2008/121/EC). Although not directly related to circularity, these might have some effects. Consumers might have preferences for certain materials based on their perception of comfort, durability, etc., which might influence which materials are used. For example by labelling t-shirts, consumers might buy more cotton shirts (or shirts with a higher cotton blend).

In addition, the EU Ecolabel has a category for textiles, which is open for clothing, although currently mostly used by a limited number of non-clothing textile producers (about 10 producers for about 1000 products). The industry also has its own voluntarily standards such as OEKO-Tex. Most of these instruments are focused on reducing harmful chemicals.

4.3.4.5 R&D stimulation

We noted that some theoretical routes are currently not used in practice, such as textile-to-textile recycling. The EU stimulates R&D activities in this field for example from the eco-innovation programme[73] on amongst others automatic material recognition and sorting by infrared sensors and the recycling of worn textile materials into new textile materials (by remelting and respinning).

4.3.4.6 Packaging Waste Directive

Although the packaging waste directive does not affect textiles (except perhaps for the rare textile-based packaging), it does have indirectly a significant impact on the use of recycled PET in polyester. Typically, as discussed, PET packaging (such as PET soda bottles) meets high quality standards and when separately collected (especially through deposit systems) a relatively clean waste stream. The packaging waste directive demands in the waste hierarchy at least material recycling for its targets, thus greatly stimulating the creation of PET recyclate in the EU. Although this recyclate has a positive economic value, currently the

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[72] There appear to be no EU statistics on this, but in the Netherlands about 4 kg per capita is collected separately (RWS Afvalcijfers database) and 3,5% of about 200 kg general waste are textiles (RWS Sorteeranalyse Restafval 2012) on a total household waste of about 500 kg per capita.

[73] E.g. Textiles-for-Textiles, Returnity/Affinity, Supertex

costs of recycling used PET far outweigh the costs of virgin PET, the packaging policy thus creates an affordable supply for the textile industry. At the same time, it might make producing recyclate from clothing less attractive as long as there is ample policy driven supply of rPET from packaging.

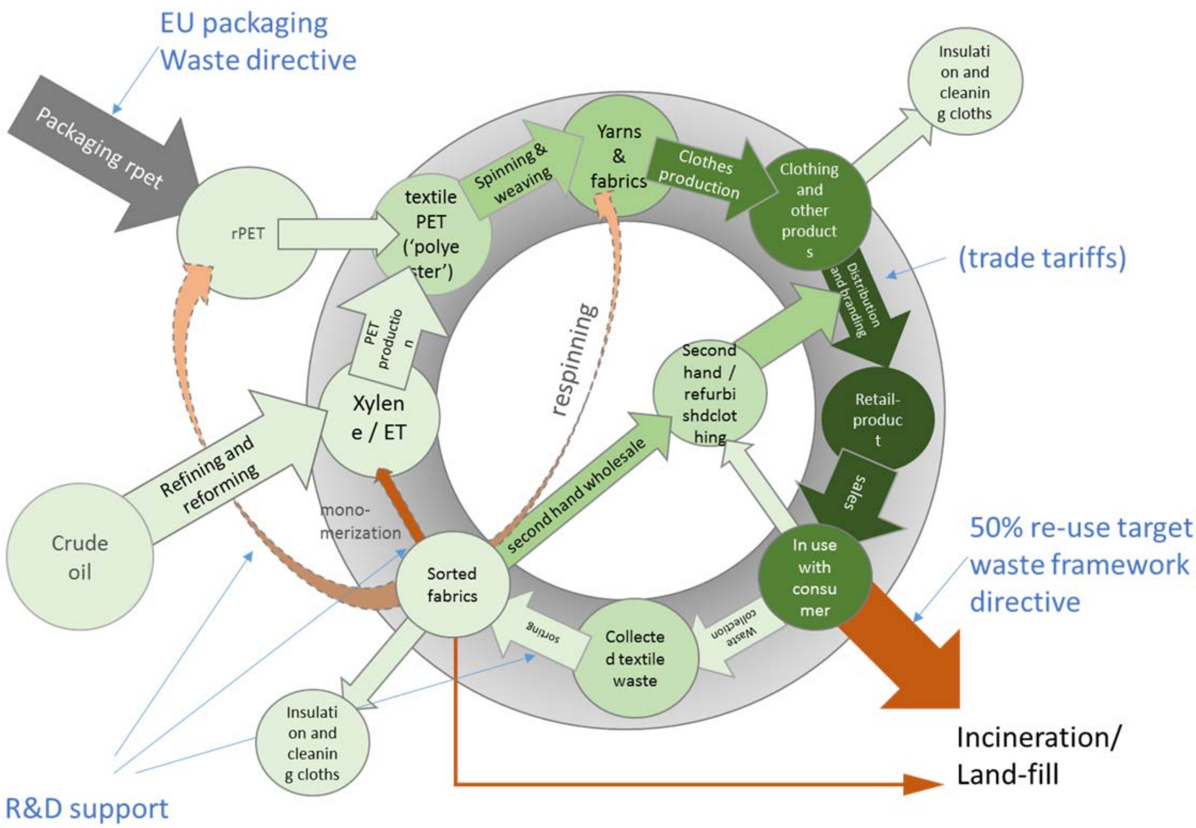

Figure 4.3.6: simplified schematic overview of materials flows in PET textiles

4.3.5 Strengths, weaknesses and future opportunities for EU policy

As there are no specific policy efforts for polyester textiles, to the best of our knowledge no systematic reviews of policy effects (or other experiences) have been undertaken. The packaging directive was thoroughly evaluated[74] and it was concluded that overall the policy has been successful in increasing material recycling rate in member states. This would also imply more recyclate to become available at a lower price for use in new products such as textiles. There are no specific statistics on how much PET/polyester is regained, let alone on the specific quality of the collected (or post-consumer separated) PET material. But it would be a reasonable expectation the EU policy increased the availability of PET packaging recyclate suitable for re-use in textiles[75].

[74] Arcadis, Bio-intelligence, Ex-post evaluation of certain waste stream Directives Final report European Commission – DG Environment 18 April 2014 & Bio-Intelligence Study on coherence of waste legislation FINAL REPORT European Commission (DG ENV) 11 August 2011

[75] Although one specific point of attention might be that deposit systems for PET Bottles, all other things equal, give a better quality recyclate than curbside collection and especially post-consumer automated separation. As the EU policy does not set quality standards, the possibility cannot be excluded that the policy stimulated mainly lower quality PET recylate.

The case demonstrates a moderately successful circular economy can emerge with very limited specific (EU) policy, but we could identify a number of potential opportunities to further stimulate circularity, besides simply decreasing losses in each step.

The EU is already involved in plastic packaging material, amongst which PET, which is on the main sources of recyclate for use in textiles. Ambitions to re-use more bottle rPET for new bottles are increasing, not only amongst policy makers, but also amongst industry. This raises the question if sufficient high quality PET recyclate will remain available for use in textiles, or textiles-to-textiles material recycling needs more urgently to be developed.

We saw that probably the most powerful actors in the chain are from the fashion and fashion retail industry. Although some of these actors are undertaking some initiative, as a whole the industry is not intensively involved in this subject. As the fashion industry is currently under pressure with regards to social sustainability and are also committing themselves to higher standards of corporate social responsibility, this might be an opportunity to broaden this agenda to include ecological sustainability and more specifically circularity. This might lead to voluntarily instruments, which could be used for better ‘design for recycling’, as we would expect the fashion industry to be able to exercise considerable power through the product chain towards both manufacturers of fabrics.

We might wonder if developments in the other major application of PET, namely PET packaging, have significance for textiles. For PET bottles, we see major brands like Coca Cola and Pepsi Cola becoming active players in the bottle-to-bottle and biobased bottle developments, including being a launching customer for PET innovations.

4.3.6 Long term policy considerations

We learned from this case study, that textiles, and especially clothing, have a strong autonomous development towards a more linear economy of ‘take-make-dispose’. Natural biobased materials are further replaced by synthetic materials, clothing items become cheaper and their life span shortens, tending towards a disposable product. The roots of these trends are long, and mass production of clothing has helped to alleviate many from literally walking in rags, but now the whole product chain is plagued by social and ecological sustainability issues, ranging from the dependency of fossil fuels, the considerable energy needed for production to persistent deplorable labour conditions in developing countries and, despite a large voluntarily textile collection sector, most textile material being limited to a single life cycle.

Conventional middle term policy measures might be able to mitigate these problems, especially as currently policy efforts are limited. Even though the supply chain is long and largely situated outside the EU, stimulating the fashion and retail industry through voluntary instruments might be feasible by including an ecological agenda to the current social agenda in these industries. Large players with more influence over the supply chain and interest in the Eco friendliness of their brand may fulfill a frontrunners role. The most important recommendation for this sector is thus to introduce voluntary agreements (‘Green Deals’) between industry and EU to stimulate sustainability initiatives throughout the sector. This is a typical frontrunner instrument, which can be followed up (if necessary) by a compulsory instrument to broaden the results of voluntary initiatives to all actors and products. On the long term, to truly address these fundamental challenges, much more radical system innovations might be necessary. Moreover, a strong long-term vision for a more economic, ecological and social sustainable textile system appears to be lacking.

4.4 Building materials

The focus on building materials is especially interesting because of the volume and weight of these materials and the energy needed for extraction, manufacturing, and transport (Berge, 2009, Icibaci and Haas, 2012). The construction industry is an important sector in the EU, providing 20 million direct jobs, together with indirect jobs accounting for 15% of total employment[76], and contributing to about 10 % of the EU's GDP77. Also in terms of material use and waste production is the construction industry one of the big players. About 40% of all materials extracted are stored in the built environment, making it an enormous reservoir of potential waste or secondary materials, to be reused or recycled[78]. Construction and Demolition Waste (CDW) is one of the heaviest and most voluminous waste streams generated in the EU, approximately 750 million tonnes per year, accounting for 25% to 30% of all waste generated in the EU[79]. It consists of numerous materials, including concrete, bricks, gypsum, wood, glass, metals, plastic, solvents, asbestos and excavated soil, many of which can be recycled, reused or recovered for energy or other purposes. In spite of the potential for recovery, rates differ between less than 10% to over 90% across the EU[80], the Netherlands being one of the forerunners with a recovery rate of over 93%, of which 95% is recycled[81].

4.4.1 Material flows

Figure 4.4.1 presents an overview of the building material lifecycle. Figure 4.4.2 gives some more context to the building material lifecycle, by showing the different activities during the lifecycle of a building, including the embodied energy in buildings, which is often not addressed when discussing the environmental effects of buildings.

[76] http://www.research.ucreative.ac.uk/2716/1/eco-design-for-the-construction-industry-brochure-uk.pdf (July, 2015)
[77] http://ec.europa.eu/growth/sectors/construction/index_en.htm (June, 2015).
[78] Kibert, 2008.
[79] http://ec.europa.eu/environment/waste/construction_demolition.htm (July, 2015).
[80] http://ec.europa.eu/environment/waste/construction_demolition.htm (July, 2015).
[81] http://ec.europa.eu/environment/waste/studies/deliverables/CDW_The%20Netherlands_Factsheet_Final.pdf (July, 2015).

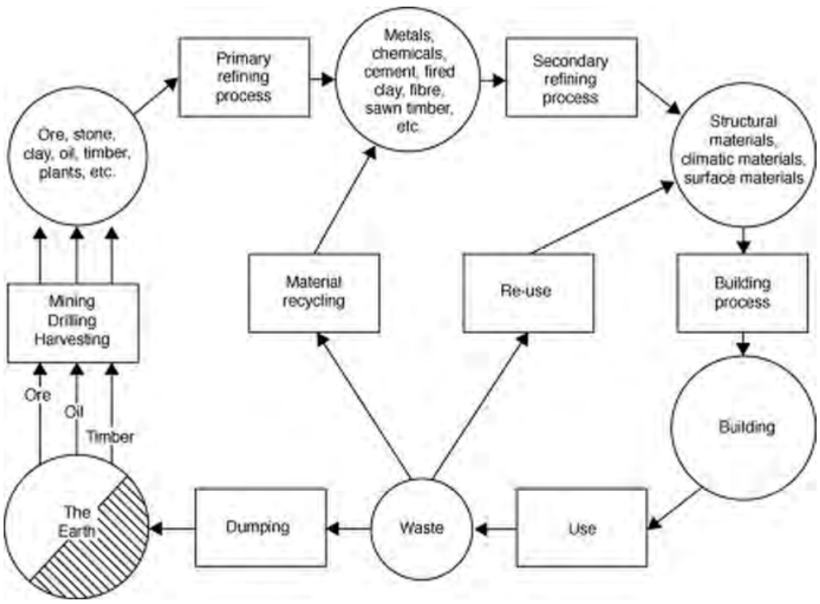

Figure 4.4.1 The cycle of building materials (Berge, 2009, p. 7)

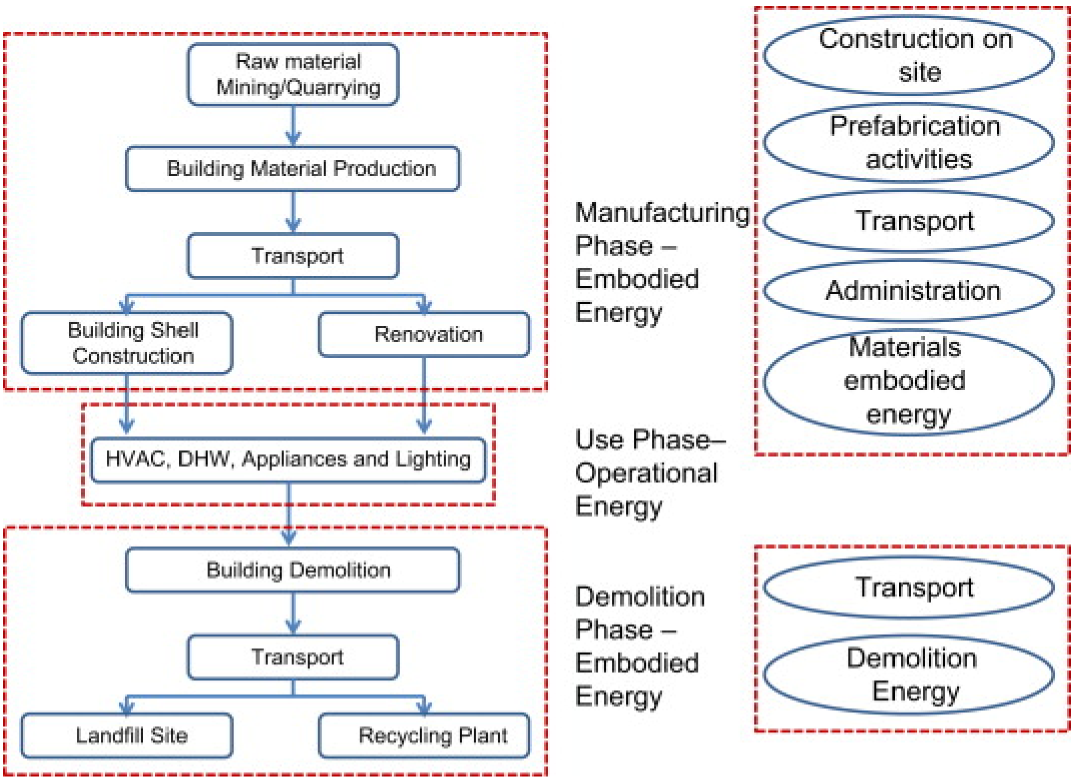

Figure 4.4.2 Life cycle of a building (Cabeza et al., 2014).

Figure 4.4.3 shows the large contribution of the construction sector to the Material Footprint (MF) per capita of the 27 Member States. This footprint, like other footprint accounting, includes material use elsewhere, beyond the nation(s) considered, needed to produce the materials imported to the nation(s) considered[82]. The figure shows that when accounted in this way, the material use is larger than when measured in terms of Domestic Material Consumption (DMC) per capita. This latter accounting mechanisms has been adopted by the EU to monitor the material use, and to relate material use over time with economic growth. Such a relationship would show whether there is a positive or negative relationship between economic growth and material use. With the material footprint measure, Wiedmann et al. (2013) show that economic growth and material use are still tightly coupled.

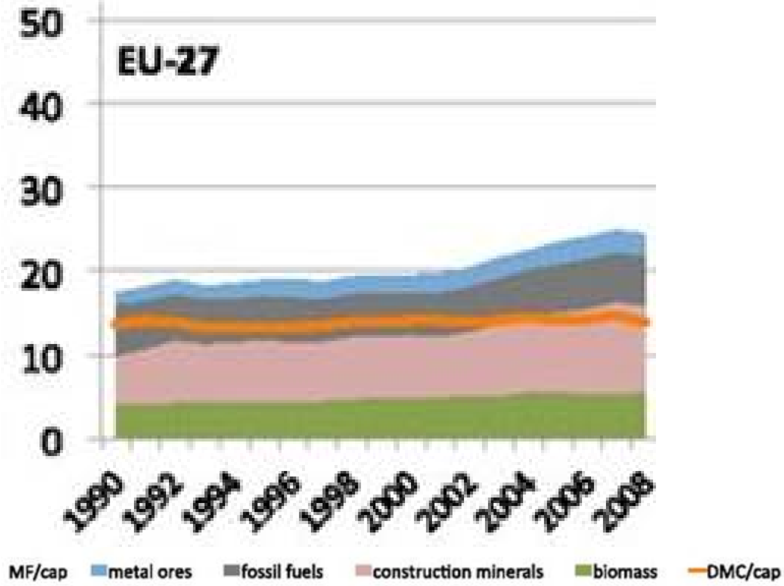

Figure 4.4.3 Material Footprint EU-27 per capita[83]

The construction industry is contributing to significant material flows. These materials are used for construction, maintenance, repair and renovation of buildings (residential and non-residential) and civil engineering works (roads, bridges, dams, etc.).
By volume used, the main flows are gravel, sand, cement, cement concrete, crushed rock, asphalt concrete, timber products, clay brick, natural stone, roofing materials, steel, aluminium, copper and other metals, plastics, paper, paints, glues, and numerous chemical products. Because of the large volumes needed, *most construction materials are of local/regional origin*[84]. With regards to the production of natural stone and gypsum, Europe produces respectively 25% and 35% of global total[85]. *Europe is self-sufficient regarding its aggregate production, and there is only limited international trade*, with the exception of Belgium and the Netherlands. In general there is a good correlation between aggregate consumption and population[86].

Natural aggregates (crushed rock, gravel, sand) that make up the bulk of Portland cement concrete and asphalt concrete are used in the largest volume. In recent years, coal combustion products (fly ash, bottom ash, and boiler slag), blast furnace slag, and foundry

[82] Thomas O. Wiedmann et al. PNAS 2015;112:6271-6276.
[83] Thomas O. Wiedmann et al. PNAS 2015;112:6271-6276
[84] Horvath, 2004.
[85] http://ec.europa.eu/enterprise/sectors/metals-minerals/non-energy-extractive-industries/construction-minerals/index_en.htm
[86] http://ec.europa.eu/enterprise/sectors/metals-minerals/non-energy-extractive-industries/construction-minerals/index_en.htm

sand have become viable replacements for natural aggregates, both in the US and in Europe. Coal fly ash has become a common substitute for up to 50% of Portland cement in concrete in the United States[87].

4.4.1.1 Raw material extraction

The construction minerals sub-sector is the largest sector in term of the tonnages of minerals extracted, and the number of companies and employees. It also has the highest turnover and value added. Typical construction minerals are aggregates (sand, gravel, and crushed natural stone), various brick clays, gypsum and natural ornamental or dimension stone[88].
The demand for construction minerals is generally high (Europe produces an estimated 3 billion tons yearly) while the cost per tonne are relatively low, requiring a tight network of pits and quarries in order to reduce transport distances and thus limit the costs of transport. The sector consists mainly of SMEs operating over 20.000 extraction sites, generally supplying local and regional markets.

Extraction of construction minerals unavoidably has a temporary and lasting impact on land use, despite land rehabilitation. Other impacts are, for example, changes in groundwater flow patterns, loss of biodiversity, dust and noise.

There is general acceptance amongst the companies active in this sector that they have to reconcile their activities with concerns for sustainable development. Besides compliances with formal regulations, there are several voluntary initiatives by sector organisations and individual companies to improve the environmental performance. For example, the International Council of Mining and Metals has produced guidelines for the mining industry to incorporate biodiversity considerations into corporate strategies and practices[89].

Demand for aggregates, gypsum and dimension stone is closely related to the level of new house-building, maintenance and repair of existing buildings and the scale and extend of civil engineering projects. During periods of weak economic growth, repair and maintenance (renovation) of the existing building stock is considered to dominate demand, and sometimes actively encouraged by national and local renovation and urban renewal programmes[90].

4.4.1.2 Improvement potential

There are a number of actions to be taken to reduce the environmental impact of the production of raw materials. With regards resource extraction Berge (2009)[91] mentions the following:

- Small(er)-scale exploitation of mineral extraction is often less damaging to the environment, especially with regards to water resources and biodiversity, but smaller scale exploitation also offers better opportunities for community involvement and restoration of ecosystem and landscape.
- Greater attention to unused resources and waste products.
- Substitution of materials that are rare and limitedly available by materials that more abundantly available, and preferably by materials that are renewable.

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[87] Horvath, 2004.
[88] Eurostat records data under NACE codes CB14.1 and CB14.21.
[89] http://ec.europa.eu/enterprise/sectors/metals-minerals/non-energy-extractive-industries/construction-minerals/index_en.htm
[90] http://ec.europa.eu/enterprise/sectors/metals-minerals/non-energy-extractive-industries/construction-minerals/index_en.htm
[91] Berge, Bjorn (2009). The Ecology of Building Materials. Routledge

4.4.2 Product manufacturing

Product manufacturing of building materials is a highly energy intensive process.

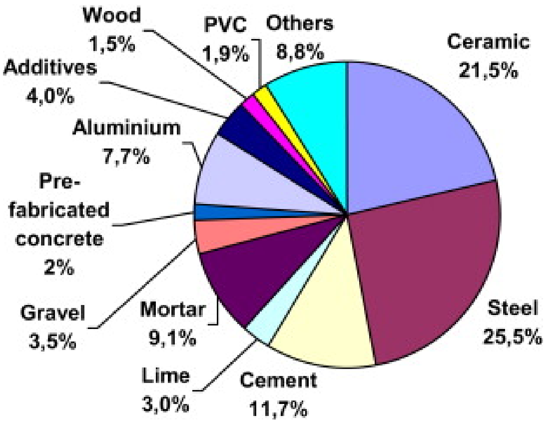


Figure 4.4.5 Contribution of primary energy demand for the manufacture of the materials needed in the construction of 1 m2 (gross floor area) (Bibrian et al., 2011)

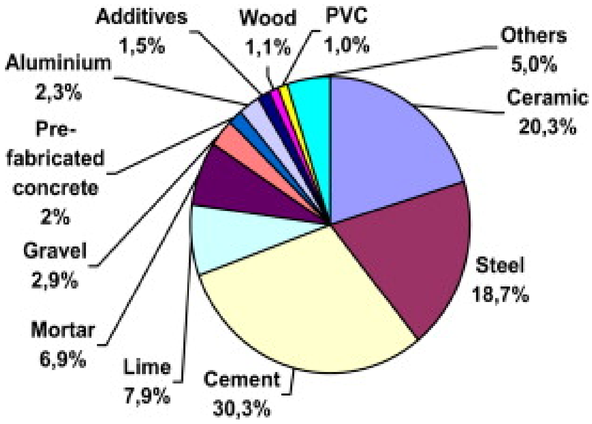


Figure 4.4.6 Contribution of CO2 emissions associated with the manufacture of the materials needed for the construction of 1 m2 (gross floor area) (Bibrian et al., 2011)

Figures 4.4.5 and 4.4.6 respectively show the energy demand of the manufacturing of building materials and the contribution to CO2 emissions. The figures emphasize the energy and carbon intensity of the manufacturing of building materials. The embodied energy is the total energy required for the extraction, processing, manufacture and delivery of building materials to the building site. In addition to the environmental effects of mineral extraction, the embodied energy is an additional important effect of building materials manufacturing. For example, concrete and cement production accounts for up to 8% of all man-made carbon emissions.

4.4.2.1 Improvement potential

During the manufacturing of building materials, the main environmental improvement potential is the increased recycling of waste products during production. Reuse of water and energy are quite commonly applied; and for example, the plasterboard industry succeeded to produce almost without waste (Berge, 2009).

The decision on which materials to use should also consider the embodied energy and embodied carbon throughout the product lifecycle.

The manufacturing of buildings usually takes place on-site. The failure costs of the industry are high, up to 10% of materials are wasted during production, often due to poor planning, miscommunication and lack of skilled labour. There is also a high volume of packaging materials. Improved planning, training and education, and waste separation on site could significantly reduce these failure costs.

4.4.2.2 Use

During use of buildings, there is continuous demand for materials, due to maintenance and repair and small and deep renovations.

The lifespan of materials is influenced by different factors: the physical structure and chemical composition of the material, the influence of the local climate, environment and use, the way it has been fitted into the building during construction and how it is maintained and repaired during use. For example, timber window frames can last longer when they are painted regularly with high quality paint. The maintenance cycle depends on the local climate (e.g. sun, wind, salty rain). When not fitted properly in the building (e.g. when pur foam was used to make the window frame ‘fit’) the opportunities for reuse reduce.

A number of drivers turn the attention of policy makers towards the use stage of buildings. In Europe, a lot of attention is paid to the reuse and transformation of existing buildings. Due to the receding and stabilizing growth of economy and population, the demand for new, additional buildings has stagnated. The focus is turning to existing buildings and how they can be transformed and reused.

The building and construction sector is one of the sectors in which the economic crisis is mostly felt. National governments consider renovation and refurbishment programmes as a means to keep the sector alive.

The requirements for increased energy efficiency resulting from the EU Energy Package and related goals call for deep renovations of buildings. With the Energy Efficiency Directive, the EC aims to increase present renovation rate of 1.2-1.4% to 3% per year, at least for government owned buildings. At present, deep renovation contributes to 15-20% of energy saving, but this could increase up to 80%[92].

4.4.2.3 Building installations: HVAC

Building installations for heating, ventilation and air-conditioning (HVAC) tend to have a shorter lifetime than the other building components, being replaced every ten to fifteen years. The HVAC industry is a worldwide enterprise, with roles including operation and maintenance, system design and construction, equipment manufacturing and sales, and in education and research. The HVAC industry was historically regulated by the manufacturers of HVAC equipment, but regulating and standards organizations have been established to support the industry and encourage high standards and achievement. The improvement of energy efficiency of buildings call for a more integrated approach with building design on the one hand, while responding to the need to be able to replace the systems without disruption (in terms of costs and demolition waste).

4.4.2.4 Improvement potential

Main improvements for the environmental building performance during the use stage of buildings thus have to do with the planning of maintenance and repairs and renovation cycles. Also during these stages, failure costs can be avoided.
Another way to prolong the time between different renovations is to increase user involvement in the management and maintenance of the building. Many renovations or floor plan changes also stem from user dissatisfaction with the building.

4.4.2.5 End-of-use: construction and demolition waste, reuse, recycle

Construction and Demolition Waste (CDW) is one of the heaviest and most voluminous waste streams generated in the EU. It accounts for approximately 25% - 30% of all waste generated in the EU (approximately 750 million tonnes per year) and consists of numerous materials, including concrete, bricks, gypsum, wood, glass, metals, plastic, solvents, asbestos and excavated soil, many of which can be recycled.[93]

[92] http://www.eurima.org/energy-efficiency-in-buildings/deep-renovation.html (July, 2015)
[93] http://ec.europa.eu/environment/waste/studies/mixed_waste.htm

“CDW arises from activities such as the construction of buildings and civil infrastructure, total or partial demolition of buildings and civil infrastructure, road planning and maintenance. Different definitions are applied throughout the EU, which makes cross-country comparisons cumbersome. In some countries even materials from land levelling are regarded as construction and demolition waste.

CDW has been identified as a priority waste stream by the European Union. There is a high potential for recycling and re-use of CDW, since some of its components have a high resource value. In particular, there is a re-use market for aggregates derived from CDW waste in roads, drainage and other construction projects. Technology for the separation and recovery of construction and demolition waste is considered to be well established, readily accessible and in general inexpensive.

One of the objectives of the Waste Framework Directive (2008/98/EC) is to provide a framework for moving towards a European recycling society with a high level of resource efficiency. In particular, Article 11.2 stipulates that "Member States shall take the necessary measures designed to achieve that by 2020 a minimum of 70% (by weight) of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the List of Wastes shall be prepared for re-use, recycled or undergo other material recovery" (including backfilling operations using waste to substitute other materials).

Despite its potential, the level of recycling and material recovery of CDW varies greatly (between less than 10% and over 90%) across the Union. If not separated at source, CDW can contain small amounts of hazardous wastes, the mixture of which can pose particular risks to the environment and can hamper recycling.”[94]

“A relatively small but increasing amount of aggregate is produced from by-products of other industrial processes, such as blast and electric furnace slags or residues from mineral processing such as china clay sands and left-overs from stone quarrying ("secondary aggregates") and from reprocessing of materials previously used in construction, including construction and demolition waste and railway ballast ("recycled aggregates").

In 2004 over 5% of the aggregates used in the EU were recycled, although the relative contribution varied greatly between Member States. At the low end, some countries report that they use no secondary or recycled aggregates, while others report that over 20% of their national consumption is met from such sources due to specific targeted national policies.

Also in the case of gypsum, alternative sources, and in particular synthetic gypsum produced at coal-fired power stations as a by-product of flue gas desulphurisation (FGD), are increasingly being used.”[95]

4.4.2.6 Improvement potential

Separation at source, during dismantling and demolition, can improve recycling and recovery rates.

[94] http://ec.europa.eu/environment/waste/construction_demolition.htm
[95] http://ec.europa.eu/environment/waste/construction_demolition.htm (July, 2015).

4.4.3 Market structure of the construction products industry

4.4.3.1 Unique type of product

Buildings are unlike individual products, which are produced under controlled circumstances and have well-defined shelf lives and finite ingredients. Buildings have a long lifespan, up to decades and centuries, but are being deeply renovated about every thirty to fifty years on average (commercial buildings have shorter renovation cycle). Buildings are often one-off products, being assembled and produced on-site with an ad hoc constellation of actors, including contractors, sub-contractors, installers, the architect, and the client. Due to the unique product, the unique production facility and the unique constellation of actors delivering the product, transaction costs tend to be high, and the opportunities for controlled production are low.

The building and construction sector is a highly fragmented sector, with many actors playing a role in the different stages of the life cycle of buildings. It is known for its conservative, risk avoiding culture. These characteristics play an important role in the slow progress towards sustainability (van Bueren and Priemus, 2005, Van Bueren and De Jong, 2007, Hofman and Henn, 2008). Long term contracts, relationships with fixed suppliers and demand for large quantities at a time make it difficult for new products or new suppliers to enter the market. Also liability concerns contribute to the risk avoiding behaviour. Especially the long lifetime of products, and the diverse influences on the product quality over its lifetime, make it more difficult to for products to be tested and certified positively.

4.4.3.2 Self-organised networks

Even though often discussed in terms of supply chain management (see for example figure 4.4.7), with a few big players dominating many steps in the supply chain through ownership or other forms of collaboration, the building and construction sector can perhaps better be viewed as a network of actors, with multiple nested networks concerned with one of the lifecycle stages of buildings (such as the material producers/manufacturers and the demolition companies) or concerned with specific part or function of buildings (such as the HVAC producers and installers). Within these sub-networks, there is often a detailed regime of formal and informal rules to which actors comply, often on a voluntary basis. The different subsectors within the construction industry all have a strong tradition of self-regulation, formulating norms and standards for compliance that are often also included in administrative regulations. Because of the high complexity and contested character of the norms and standards, government has to rely on the self-organisation by the sector.

4.4.3.3 Green building initiatives

In addition to the self-organisation at sub-network level, the building and construction sector has also organized itself on a sector level. Some of these organisations, often named ‘green building council’, explicitly focus on the sustainability and environmental performance of buildings, for which a label or certificate is being issued. These systems take the whole building performance into account, focusing on different environmental and social aspects throughout the lifecycle of a building. These voluntary initiatives typically move beyond mandatory requirements. The organizations have a membership structure, meaning that the members influence the content of the requirements. Ideally, the certification requirements keep in pace with regulatory requirements, which set minimum standards and requirements for the entire sector. The labels and certificates aim at clients who want to perform well beyond what is legally required. When legal requirements increase, the certificates should demand higher performances as well. In this way, there is a push and pull between legal requirements and voluntary, beyond legal requirements. The certification systems also provide a test bed and niche market for innovative products.

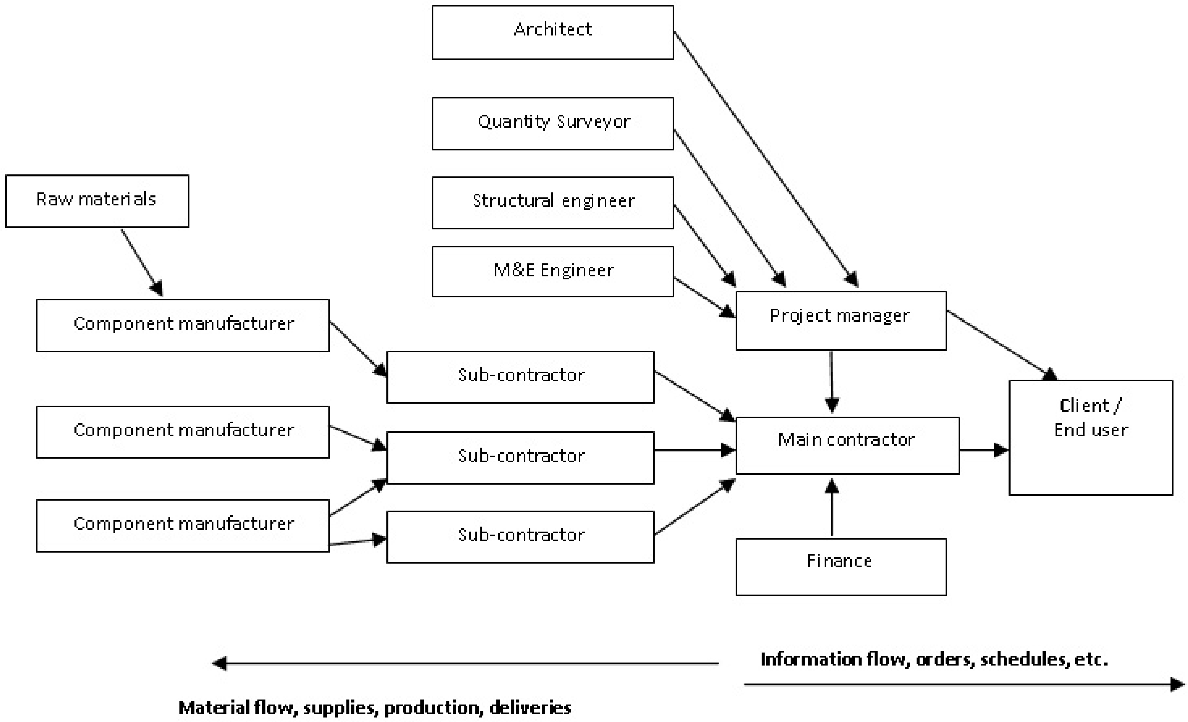


Figure 4.4.7 The construction supply chain[96]

4.4.4 Strengths and (future) challenges in the construction products industry

The focus on whole building performance provides a great impetus for design-for-environment in the building and construction industry. The environmental performance of buildings and the opportunities for reuse and recycling all start with the building design. In the design stage, choices for materials, function and performance are made. The client has a great influence on these choices, but usually the client is not trained or experienced in this field and due to the long lifetime of buildings, clients are usually inexperienced with commissioning such projects. Voluntary standards and certification schemes for green building turn out to be a great help for clients to formulate their demands, but also for mainstream construction companies to deliver sustainable buildings.

In addition, there are certain directions in which the construction industry could further develop which will help to reduce the demand for raw materials and improve the reuse and recycling of building materials.

4.4.4.1 Building information modelling

With the increased availability of modelling techniques and of building information, modelling the building from the design stage will help to improve the design and monitor and understand the performance of the building and the different components throughout its (sometimes very long) lifetime.

[96] https://consultations.rics.org/consult.ti/construction_sectors (July, 2015)

4.4.4.2 Flexible, adaptive building

By separating the different layers of a building (structure and infill such as cabling/wires, floorplan, flooring, bathroom, kitchen, etc.) the different components can be replaced according to their lifetime of performance, without disruption. Buildings can also more easily be adapted to changing demands, contributing to the lifespan of a building. The ability of easily separating short-cycled products from the long-cycled building structures greatly supports the opportunities for circularity of these short-cycled products. It also stimulates suppliers to develop new Product Service Systems. There are already first lease models for HVAC-installations on the market. For a specific brand of soft carpet tiling there is already a return logistics in place. These models for leasing and return, fostering reuse and recycling, could also lead to a more up to date use of best available technologies, for example, when lease contracts include the energy use of the products, it is in the interest of the producer to make sure that products are as energy efficient as possible. Models for leasing or return could perhaps even extend to products with a medium termed lifecycle, such as bathrooms and kitchens, replacement of which usually produce a lot of waste.

4.4.4.3 Dematerialization

The 'dematerialization' of buildings is an important issue in sustainable construction, pointing towards the need to use less material for building construction, for example by using hollow bricks that reduce material and energy demand of these products, or by replacing materials with substitutes with a better environmental performance. Also, transport costs and transport related emissions go down. For example, castellated steel beams can use 25-50% less steel than traditional beams and reduce costs by some 44 Euros per meter[97]. However, safety and liability concerns and quality and performance standards are often mentioned as institutional barriers to product innovation and to the use of alternative materials and products.

4.4.4.4 Market challenges: lack of demand, oversupply and competing markets

Building materials for which there is a market demand are already reused and recycled. For example, copper, aluminium and zinc have a near 100% recycling rate. However, for many other materials the reuse and recycling rate is low due to low value and lacking demand. For example, for end-of-life concrete there is only a demand for low value, downgraded recycled aggregates, which is used as foundation for road construction. This is a cheap resource for the road construction industry. However, in the near future demand for road foundation materials will decrease while supply will increase. End-of-life concrete will, just as many other end-of-life building materials, thus have to find a new function, preferably in a less downgraded form.

There are opportunities for recycling the end-of-life concrete in a less downgraded form. There have always been concerns for quality with regards to the reuse of these recycled aggregates in concrete, for example in terms of stable size and shape of the particles, affecting the workability, compressive strength and durability of concrete. New recycling technologies have addressed these concerns and crushed aggregates now match the quality demands, as also laid down in norms and standards, and can be reused as secondary material in concrete (see fig. 4.4.8).

However, the business case for developing recycling technologies is difficult. Investments are high while revenues are uncertain. They highly depend on the volatile price setting of competing raw materials, whereas investment costs are stable. Also, in some supply chains, producers also own the quarry, which gives them no incentive to use recycled materials over natural ones. Investors therefore seek to keep process costs of recycling as low as possible.

[97] http://www.research.ucreative.ac.uk/2716/1/eco-design-for-the-construction-industry-brochure-uk.pdf

A final point of concern is the competition between markets. For example, the recovery of waste for energy production offers a cheap and easy way for disposal of end-of-life materials, further complicating the development of sound business cases for recycling. The demand for recycled aggregates in road construction had a similar effect. When materials are widely available – which construction products usually are - and a relatively cheap resource for another product, there are no incentives for producers to look for substitutes, or to develop (higher quality) recycling. Another example of competition between markets and trade-offs between values concerns the use of fly-ash, a waste product from power plants, in concrete. Replacing 30% of cement with fly-ash for producing structural concrete reduces the embodied carbon from 180-17kg per tonne[98]. However, also the fly-ash is waste product that should be avoided. The transition to renewable energy sources could be slowed down because there is a market for carbon energy by-products, which affects the business case of alternative, non-carbon energy sources.

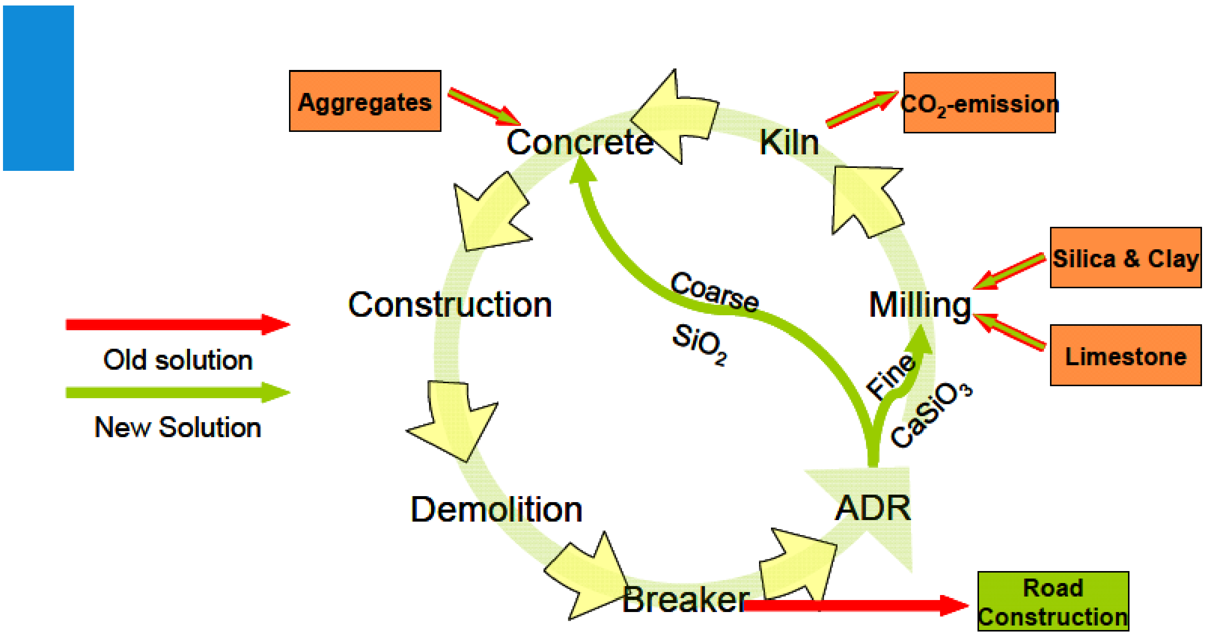


Figure 4.4.8 Old and new ways to recycle end-of-life concrete (Di Maio et al., 2014)

4.4.5 Regulatory instruments relevant to the circularity of construction products

The construction industry is known for its self-regulatory capacity. There are two explanations to this. Firstly, the formulation of legal or administrative regulation requires detailed knowledge of the topic to be regulated. However, the knowledge needed for regulations, e.g. on material performance, is ambiguous and contested (e.g. van Bueren, Klijn and Koppenjan, 2003). Secondly, compliance is difficult to monitor and enforce without the industry's support. To avoid administrative regulations and standards that are contested by the industry and show high levels of non-compliance, it is best to stimulate the industry to forms of self-regulation. In building and construction regulation, it is common practice that this well-organised sector takes a leading role in the setting of standards and regulations.

[98] http://www.research.ucreative.ac.uk/2716/1/eco-design-for-the-construction-industry-brochure-uk.pdf (July, 2015)

The structure of the building sector allows for this regulatory co-creation process. Within the different chains and networks to be identified within the sector, there are a number of big players and branch organisation that have enough power to enforce and create commitment to joint minimum standards and regulations. At the same time, it is important that governments challenge the sector to raise ambitions over time. The EU plays a big role in providing these challenges. Table 1 lists a number of policy instruments used by the EU to challenge and enforce the construction industry to improve the sustainability of their products and processes.

EU Policy instruments

EU Policy Instrument	Aim	Means
Energy Performance of Buildings Directive (EPBD) (2010/31/EU)	Improvement of buildings' energy performance, taking into account climatic and local conditions, indoor climate requirements and cost-effectiveness. All new buildings shall be nearly zero-energy buildings by 2020.	• Certificates (Labels A to G) and inspections. Every building or building unit needs a label. • The labels are supported by a set of European standards. • Compulsory for new buildings, enforcement through building permit procedure. • Compulsory for existing public buildings and for all existing buildings when sold.
Energy Efficiency Directive (2012/27/EU)	Framework of energy efficiency promoting measures to step up Member States' efforts in this field.	• Each MS should draw up a roadmap to make the entire building sector more energy efficient by 2050. • Public authorities should set the example: renovate each year 3% of central government buildings. • Energy companies are requested to lower their energy supply to customers with 1,5% annually, for example, through retrofitting of buildings and improved HVAC systems.
Green Public Procurement (GPP)	Voluntary, but key instrument in EU's resource efficiency policies.	• Public authorities should use their purchasing power to buy green products and thus stimulate innovation and set the example. This provides them with incentives that are not available within public policy. • Sets of purchasing criteria and support tools (e.g. LCC).
Waste Framework Directive (2008/98/EC)	Reaching 70% of preparation for reuse, recycling and other forms of material recovery of	• MS produce factsheets and roadmaps. • Possible instruments to be

	construction and demolition waste by 2050.	used by MS: Landfill taxes, levies, recycling targets, waste management plans for construction and demolition sites, public awareness raising, etc.
EU Lead Market Initiative	Lower barriers for new products or services.	• Improve efficiency of regulatory framework, standardization and public procurement practices. • Upgrade skills of construction workers.
Eurocodes	Series of European standards providing a common approach for the structural design of buildings and other civil engineering works.	• Eurocodes are implemented and used in EU and EFTA. • Advantage of using Eurocodes: update/upgrade of national standards, access to EU-market. • Next generation of Eurocodes aims to include even more materials, performance requirements and design methods, also with regards to the assessment, reuse and retrofitting of existing structures, as well as enhanced robustness requirements.
Construction Product Regulation (CPR) (Regulation No 305/2011)	Facilitate free movement of engineering and construction services and contribute to the competitiveness of the sector, especially in the field of sustainability by formulation and implementation of product standards for construction works, including hygiene, health and environment; energy economy and heat retention; and sustainable use of natural resource.	• CE-marking (a declaration that the product confirms to all applicable provisions and the appropriate conformity assessment procedures have been completed). • Declaration of Performance (DoP): construction products not fully covered by a harmonized standard requires a technical assessment.
Eco-design of Energy Related Products Directive (2009/125/EC)	Framework directive allowing standard setting for minimum environmental performance for many product groups	• Generic and specific requirements for energy-using products and energy related products (many building components are amongst the second group).

4.4.6 Strengths, weaknesses and future opportunities for EU policy

Reuse, recycling and recovery of building materials is something that the building industry automatically provides for when there is a financial incentive. Over the past decades, national legislation has already incentivized construction industry to reduce waste, with some very successful examples. For example, the ban on landfill policies in the Netherlands have led to an almost 100% rate for reuse, recycling and recovery, albeit in a low quality. At the same time, this has led to a wide variety of practices and achievements, making it difficult to formulate EU policies with enforceable, joint ambition levels. This is in line with an exploratory research into the possibilities for more homogeneity in EU sustainable construction regulation to stimulate a lead market (Van der Heijden et al., 2013). One of the conclusions of this study was that many of the achievements in the field of sustainable construction were not directly resulting from the EU policies and directives, but were indirectly pushed and pulled by local authorities, end-user demand and industrial players.

Where the EU policies turn out to be a great help is in the harmonization of technological standards and methods, in the form of formalized standards, such as the CE mark and the Eurocodes, or in the contribution to the development of (harmonized) decision-support methods and tools that stakeholders in the building and construction sector can use to determine and communicate environmental product performance, such as LCA and LCC methods.

The two-tier track – even though probably not intended as such – of policies aimed at building materials and building products on the one hand and at whole building performance on the other hand seems to combine very well. For example, the Energy Efficiency Directive and the Eco-design directive push producers of energy using products to design for reuse and recycling, which in turn triggers stakeholders involved in whole building design to adapt the building design in such a way that elements with different lifecycles can be separately deconstructed – something which is very difficult to regulate at a whole building level. In turn, at the whole building performance level, voluntary, industry-run certification schemes are leading. The self-regulatory character of these schemes provide legitimacy, credibility and acceptance of these programmes amongst the sector. The ambition levels of these schemes are pushed upwards by EU or national regulations targeting the performance of specific building materials, products or components, which in turn enhances the credibility of these programmes.

Local authorities are playing an important role in stimulating change in construction and the built environment. At the moment, they are very much focused on the energy transition, stimulating and facilitating the transition towards renewables and low carbon communities. Again, EU policy indirectly contributed. For example, with the introduction of the Energy and Climate Package, the Covenant of Mayors was launched by the EU to provide local authorities a platform to voluntarily formulate an action plan to achieve the EU ambitions and share their experiences. This has become a huge success, with over 5800 local authorities participating.

Last but not least, green procurement strategies are having effect. They set tangible targets for specific government organisations at specific administrative levels. Even though also this is often of a (semi-)voluntary nature due to the absence of sanctioning mechanisms, it helps government in the formulation of policies and development of practices for sustainable construction, also in collaboration with the local construction sector. After all, many construction projects and the participating actors are of a local character.

4.4.7 Long-term policy considerations

To speed up the transition towards a circular economy with regards to building materials, attention needs to be paid to the demand for used and recycled building materials. Without a market demand, it will be difficult to make breakthrough changes. Creating a market demand for recycled materials will imply big changes of supply chains. Especially vertically integrated chains, where manufacturers also own the quarries and have a strong position in the global market, are difficult to influence.

Technological innovation may contribute to the creation of a market demand. For example, the development of a building material using recycled aggregates may reduce the demand of primary resources, and will reduce the negative environmental effects of mining and first processing.

Other effective policies will be the ones that influence the incentives for recycling and the development of recycling technologies. The implementation of the waste directive in the various MS and the achievement of the targets could already provide strong incentives. At the same time, fact sheets about current waste collection and landfill practices show that this is a highly decentralised activity, with out-dated technologies and insufficient infrastructures.

4.5 Wood products

The wood sector consists of forest resources and the production, trade and consumption of forest products and services[99]. The EU contains 5 % of the world's forests and EU forests have continuously expanded for over 60 years, although recently at a lower rate due to a growing stock of ageing trees. EU Forests and Other Wooded Land now cover 155 million ha and 21 million ha, respectively, together more than 42 % of EU land area[100]. About 75% of that area is potentially available for wood supply, harvesting the remaining 25% is not possible due to ecological and legal restrictions[101]. The restriction to the area potentially to be harvested puts a cap on the EU wood production. Innovation thus plays an important role in the increase of wood production, as well as recovery of wood[102].

Wood is popular for multiple reasons: it is renewable, it has various reuse and recycle options it is durable, it can be produced locally, its carbon balance is superior compared to other products – timber is a low embodied energy material, it is a multi-purpose raw material, it is a light material with a high strength to weight ratio, and the 'production sites' (forests) have positive by-effects for nature (biodiversity, climate) and recreation[103]. Wood is the most important product delivered by forests[104], about 70% of the wood in the EU is used in construction and furnishings[105]. Other industries using forest products are the pulp and paper industry and the printing industry, and more recently, the energy industry. These cover downstream activities that use the output of the initial harvested wood. Only part of the any log or tree can be used for sawn or veneer products, the remainder can be used for sheet products, paper or cardboard.

Wood can be processed in many ways, into many types of products with extremely low added value (burnt as wood chips or pellets for energy generation) or extremely high added value (furniture industry). Within each of the different value chains that can be identified within the wood-based sector, there are opportunities for improving the environmental

[99]http://www.lenzing.com/fileadmin/template/pdf/konzern/lenzinger_berichte/ausgabe_87_2009/LB_2009_Teischinger_1_ev.pdf (August, 2015).

[100] http://ec.europa.eu/environment/forests/home_en.htm (August, 2015)

[101] file:///H:/Circular%20Products%20Initiative/indufor-report-part1_en_Wood%20Raw%20Material%20Supply.pdf (August, 2015)

[102] file:///H:/Circular%20Products%20Initiative/indufor-report-part1_en_Wood%20Raw%20Material%20Supply.pdf (August, 2015)

[103] http://www.egger.com/downloads/bildarchiv/187000/1_187099_DV_Real-potential-changes-growth_EN.pdf (August, 2015)

[104] Non-wood products delivered by forests are cork, resin, tall oil and taxol; these products are especially of significance for the local economy. http://ec.europa.eu/growth/sectors/raw-materials/industries/forest-based/sustainable-forest-management/wood-other-products/index_en.htm (August, 2015)

[105] http://ec.europa.eu/growth/sectors/raw-materials/industries/forest-based/woodworking/index_en.htm (August, 2015)

performance and increasing the recovery of wood, especially of the so-called side streams of wood processing. The different value chains are connected through markets: especially the demand for low added value wood is of influence on the profitability of and conditions for innovation. The opportunities for cascading, using wood products in their consecutive lifecycle stages according to their different qualities, are considered high. The opportunities for reuse, recovery and recycling have been described in separate sectorial studies for furniture and for the paper, pulp and printing industry. This chapter will focus on the wood and wood products manufacturing sector. In addition, it will also reflect on the opportunities of vertically integrated supply chains may have to offer for circularity, since most of the recovered wood is reused or recycled within wood-based sectors[106].

4.5.1 Material flows and conversions in the wood (products) manufacturing chain

4.5.1.1 Raw material extraction

The wood and wood products manufacturing sector includes the first processing stages of sawmilling and planing of wood and the downstream activity of the manufacture of products of wood, cork, straw and plaiting materials, referred to as wood products manufacturing. Many of the side-flows of roundwood and wood products manufacturing is use in the pulp and paper industry.

The European Union and the United States lead global timber and pulp consumption. As a single market, the EU is the largest consumer of timber products in the world[107]. Figures 4.5.1 and 4.5.2 show global timber and pulp production and demand, including the EU-27. In 2012 the EU-28 was the largest producer of roundwood within the G20[108].

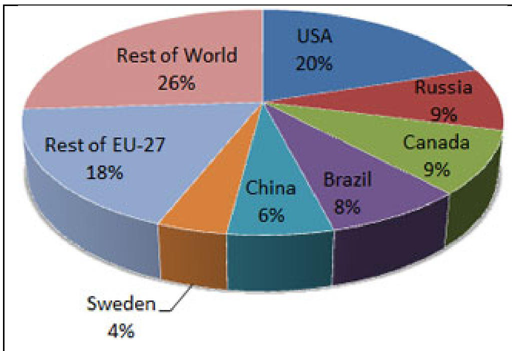


Figure 4.5.1 Global timber and pulp production, including all round wood, excluding wood fuel (5 year average by weight 2007-2011) Source: FAO 2010[109].

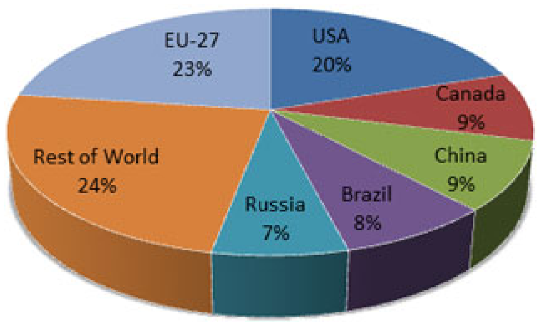


Figure 4.5.2 Global timber and pulp consumption, including all round wood, excluding wood fuel (5 year average by weight 2007-2011). Source: FAO 2010[110].

Around 97% of the raw wood processed in the EU comes from sustainably managed EU forests; the rest is imported.[111] For the imported wood and wood products, the legal status is difficult to trace.

[106] https://ec.europa.eu/eip/raw-materials/en/system/files/ged/53%20Annex%20-%20Wood%20flows%20in%20Europe%20Mantau.pdf (August, 2015).
[107] https://www.cdp.net/en-US/Programmes/Pages/forests-timber.aspx (August, 2015).
[108] http://ec.europa.eu/eurostat/statistics-explained/index.php/The_EU_in_the_world_-_agriculture,_forestry_and_fisheries (August, 2015).
[109] As published on: https://www.cdp.net/en-US/Programmes/Pages/forests-timber.aspx (August, 2015).
[110] As published on: https://www.cdp.net/en-US/Programmes/Pages/forests-timber.aspx (August, 2015).
[111] http://ec.europa.eu/growth/sectors/raw-materials/industries/forest-based/woodworking/index_en.htm (August, 2015)

Forest productivity varies significantly among Member States (a net annual increment of 0.9 m^3 per ha in Cyprus and 13.4 m^3 per ha in Denmark). Based on comparison of EU annual felling and net annual increment, it is concluded that, on average, 60%-70% of the annual increment is cut. The stock in the EU is thus growing, even though accessibility and speed of growth will also influence the harvest potential.

4.5.1.2 Product manufacturing

There are many different products and production processes in the wood value chain. Figure 4.5.3 shows an overview of the products manufactured from roundwood.

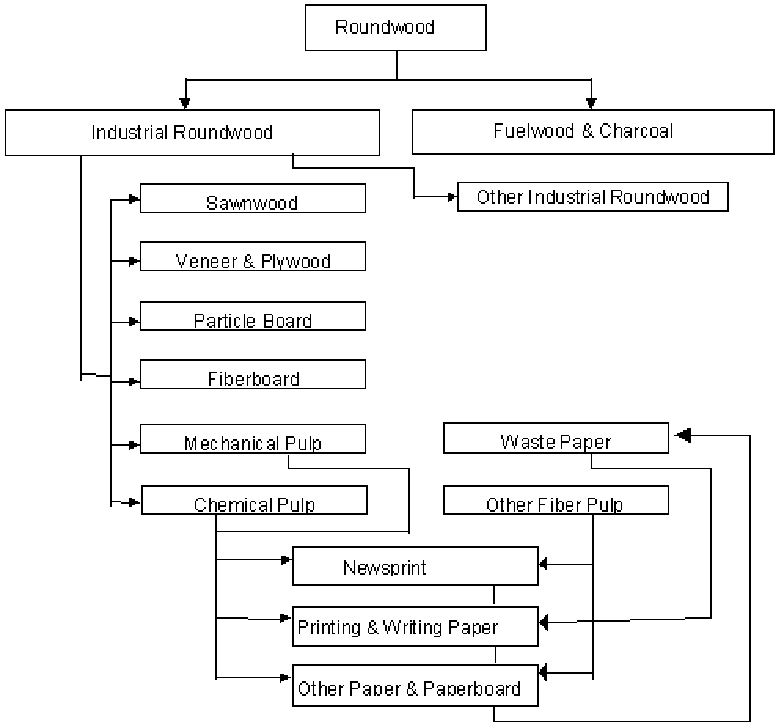
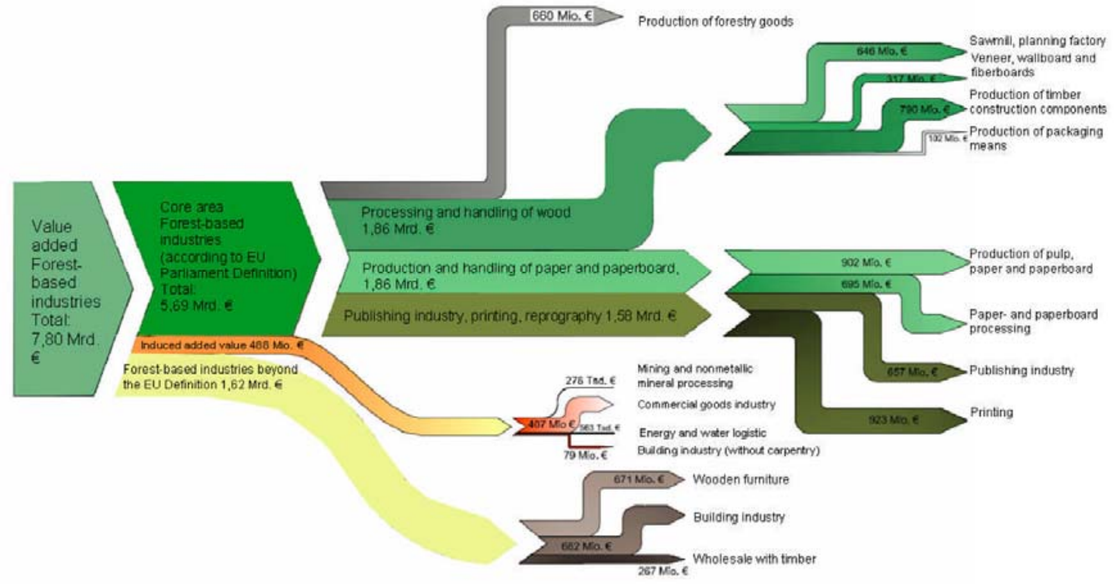


Figure 4.5.3 Roundwood products[112]

Within this research we have not been able to identify an integrated overview of the EU wood processing and / or wood product manufacturing value chain. Figures are either per subsector, per country or based on particular data sets. Two figures are presented here that together give an impression of the overall value system. Figure 4.5.4 represents the wood value chain in Austria. Figure 4.5.5 represents a global overview of the material flows for the paper and pulp value chain as presented in a World Economic Forum publication – it is stated that this figure has been the result of a combination of multiple data sources and interviews with experts. The paper and pulp industry are characterized by a high diversity of products. Pulp, paper and packaging boards are typically half-products[113].

[112] http://www.fao.org/docrep/003/x1674e/X1674E12.htm (August, 2015).
[113] http://www.efi.int/files/attachments/publications/efi_wsctu_6_2014.pdf (September, 2015).



Green streams: account for the EU-statistics for the forest-based sector, Orange stream: induced value added in downstream branches, Yellow/grey streams: furniture, wholesale trade and wood-related construction sector which is accounted for the forest-based sector in Austria but not in the EU-statistics

Figure 4.5.4 Value chain and added value of the forest-based sector in Austria in 2004[114]

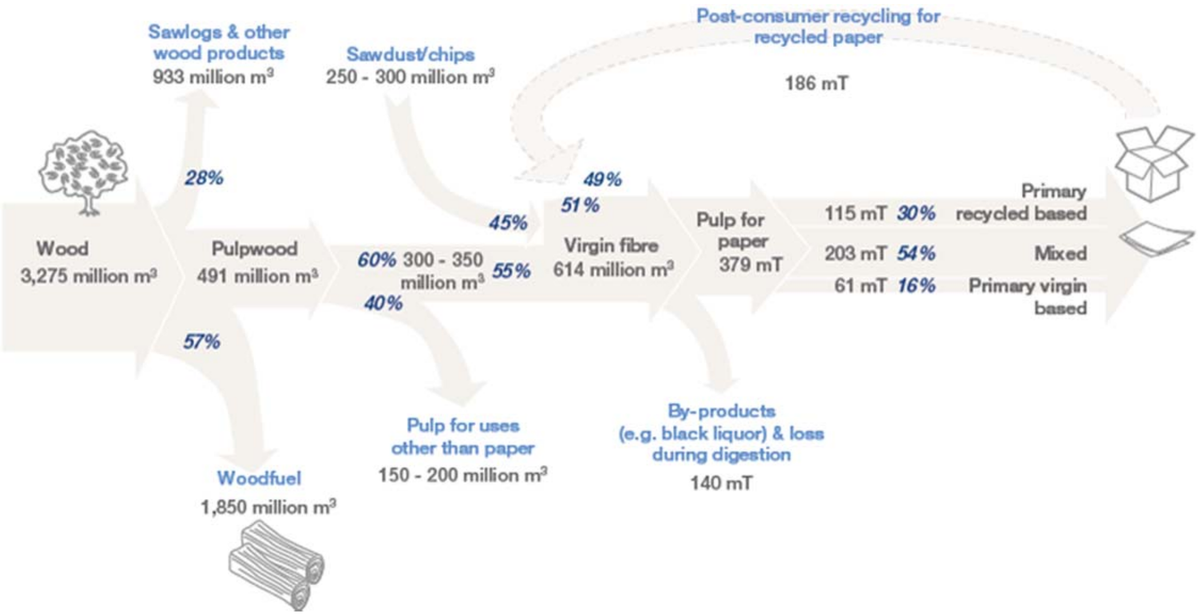


Figure 4.5.5 Fibre flows in the pulp and paper value chain[115]

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[114] Neubauer F-J (2009) Die Wert- schöpfung der österreichischen Forst und Holzwirtschaft inklusive nach gelagerter Branchen. Schriftenreihe des Instituts für Marketing und Innovation, Band 2, Universität für Bodenkultur Wien, ISSN 2074-1022, as published in Lenzinger Berichte 87 (2009).

[115] http://www3.weforum.org/docs/WEF_ENV_TowardsCircularEconomy_Report_2014.pdf

Besides wood, the forest-based industries also use other materials in their manufacturing, as presented in table 4.5.1.

Non-wood materials used in forest-based industries	**Explanation**
Resins and adhesives	Used in making wood-based panels, for example to bind together the alternating lamellae of plywood. Many widely used adhesives are based on various combinations of urea-formaldehyde and/or polyurethane. Formaldehyde has recently been listed under REACH as a carcinogen and its use may be restricted and replaced with less toxic adhesives.
Surfacing and coating	Many wood-based materials are covered with other materials for a more pleasing aesthetic effect. They may also be coated to enhance their protection against wear or moisture. The latter is most often achieved by using paints and varnishes. Some wood-based panels, such as particleboard, can be rendered water-resistant by applying a surface layer of polyurethane.
Latex	Liquid natural rubber can be added to the surface of paper to improve its strength and printability.
Starch and kaolin	Used in the body of paper to improve strength, printability, smoothness, and water-resistance.
Solvents	Used in the manufacturing processes of EU forest based industries, especially in the printing industry. While printing inks are increasingly water-based to improve the recyclability of printed paper, organic solvents are still needed for lubrication and cleaning.

Table 4.5.1 Non-wood materials used in forest-based industries[116]

4.5.1.3 Use

Wood products have a long lifetime. Durability of wood can further be enhanced by design detailing to minimize exposure to hazards as fire, weather conditions and fungi. Also treatment can enhance the durability. The stock of wood used in furniture and material products is increasing: more wood is being produced than is collected for reuse, recycling and waste disposal.[117]

Through the cascading wood – the wood products will be used and reused in sequence for different purposes, matching the remaining quality of the wood products, the lifetime can significantly be enhanced. For example, the useful service life of pine wood could be extended from 75 years to over 350 years. Examples of successive use of the wood are floor joists, floorboards, window frames, flakeboard, fiber board and energy recovery through combustion.[118]

4.5.1.4 Collection and processing

Figure 4.5.4 shows the cascading use of wood resources in the wood products chain, including the recovery cycles. Especially for the paper and pulp industry recovery rates are high. The durability of wood products and the end products they are used for (e.g. construction, furniture) has repercussions for the recovery potential of wood products. In 2010, 69% of the overall potential of post-consumer wood was recovered in the form of material recovery or energy generation. This is only 22.3% of the total market volume. The

116 http://ec.europa.eu/growth/sectors/raw-materials/industries/forest-based/sustainable-forest-management/wood-other-products/index_en.htm (August, 2015)

117 OECD (2012) Environmental Outlook to 2050, in: http://infographics.pbl.nl/biomass/PBL-2014-biomass-wishes-and-limitations-1531.pdf (September, 2015)

118 Fraanje, P. (1997) in: Sathre, R., & Gustavsson, L. (2006). Energy and carbon balances of wood cascade chains. Resources, *Conservation and Recycling*, 47(4), 332-355.

difference can be explained by the long storage time of wood products in use. Only about one third of the wood consumption is potentially post consumer wood (Mantau, 2012).

In contrast to the wood manufactured products, the paper and pulp industry is characterised by very short lifecycles and recovery rates up to 50% in the EU. In the report of the World Economic Forum on the Circular Economy, paper and cardboard are labeled as 'golden oldies', together with PET, glass and steel. 82% of the raw materials for paper and pulp production are sourced from responsibly managed forests in Europe. The products have "well-established, high-volume recyclates with a remaining purity challenge."[119] Collection rates are high, leading to an average recycling rate of paper of 40% in 1991 to 71.7% in 2012. Recycling rates of paper and board packaging is even the highest of all material recycling in the EU: 81.3% in 2011. However, during the reverse cycle there is a quality loss and ink contamination, accounting for an estimated value loss of US$ 32 billion annually[120]. The quality loss has to do with the weakening of the fibres after each time of recycling; after 6 times the quality is about 20% - 30% less compared to virgin fibres. The mixing of recycled fibres with virgin fibres can again raise the quality of the paper and cardboard produced[121]. In the EU, on average, paper fibres are recycled 3.5 times, with 6 to 7 times being the maximum[122]. Current transport prices for recycled paper and cardboard are low due to structural imbalanced trade flows across the globe; they are perfect products to fill the empty containers going back to China and other countries. With the price of virgin materials for paper and cardboard being almost twice as high as the price of recycled materials, the use of recyclates is attractive, as well as closing the loop at a global level.[123]

4.5.2 Market structure

Table 4.5.1 shows some important industries using wood and wood-based products. Because of the wide diversity of production processes and usages, it is difficult to give an overall picture of the market structure including these different types of industries. From a supply side perspective, other categorizations can be made: raw wood, semi-finished wood products and finished wood products, with least value added to raw wood production and highest value added with finished wood products as furniture. Member States with more forests are characterised by more specialisation within the wood and wood products manufacturing sector[124].

[119] http://www3.weforum.org/docs/WEF_ENV_TowardsCircularEconomy_Report_2014.pdf
[120] http://www3.weforum.org/docs/WEF_ENV_TowardsCircularEconomy_Report_2014.pdf
[121] http://www3.weforum.org/docs/WEF_ENV_TowardsCircularEconomy_Report_2014.pdf, page 34.
[122] www.cepi-sustainability.eu/uploads/short_sustainability2013.pdf (September, 2015)
[123] http://www3.weforum.org/docs/WEF_ENV_TowardsCircularEconomy_Report_2014.pdf
[124] http://ec.europa.eu/eurostat/statistics-explained/index.php/Manufacture_of_wood_and_wood_products_statistics_-_NACE_Rev._2#Sectoral_analysis (September, 2015)

Table 4.5.2 EU Forest-based industries and their features[125]

Forest-based industries	Characteristics	Employment	Annual turnover	Environment	Recycling	Innovation
Woodworking industry		1.093 million workers in 184 000 SME's (except for woodbased panel sector)	EUR 122 billion	Due to the carbon retention feature, harvested wood products have a smaller carbon footprint than products from competing materials.	Used (post-consumer) wood is not recycled to its full potential, esp. recovery from buildings (new and renovated) can be improved.	Engineered wood products have a more predictable and consistent performance than natural wood.
Furniture industry	Labour-intensive, creative, responsive to new demands	1 million workers in 130 000 companies (SME's)	EUR 96 billion		Many side streams are produced and can be recovered more and/or in higher quality.	EU is world leader in high end segment (about 2/3 market share globally)
Pulp and paper industry	Energy and raw materials intensive industry with high capital costs and long investment cycles.	647000 workers in 21000 companies	EUR 180 billion	Biomass is used for >50% of the industry's primary energy use, contributing to self-sufficiency and carbon emissions reduction.	Voluntary industry-led initiatives have led to a paper recycling rate of >70%. Raw materials come from sustainable sources.	Innovative industry, high expertise (esp. wood fibre), R&D, exploitation of new business models, aiming to maximize value. Pioneering industry in low-carbon bioeconomy.
Printing industry		770 000 highly skilled workers in 120 000 companies	EUR 88 billion (printing on paper, plastics, textiles.)	Environmental voluntary and non-voluntary regulations.	Residues have potential for reuse.	

As table 4.5.3 shows, there is a high difference between the value added by the different types wood processing and product manufacturing – some have very low added value, others very high.

[125] http://ec.europa.eu/growth/sectors/raw-materials/industries/forest-based/ (August, 2015)

	Sawlogs			Pulpwood			Forest residues		
	Per unit product	Per unit biomass input (A)	Per ha-yr	Per unit product	Per unit biomass input (A)	Per ha-yr	Per unit product	Per unit biomass input	Per ha-yr
Ethanol (GJ)	-1.4	-0.6 (-4)	-9	2.7	1.1 (7)	11	3.4	1.3	10
Methanol (GJ)	2.0	1.3 (9)	21	4.5	3.1 (20)	30	4.8	3.0	24
Dimethyl-ether/ DME(GJ)	0.5	0.4 (2)	6	3.0	2.1 (13)	20	3.4	2.1	17
Fischer-Tropsch-diesel (GJ)	-0.4	-0.2 (-1)	-3	2.9	1.5 (10)	15	3.4	1.6	13
Pellets (GJ)	-1.0	-0.9 (-6)	-14	0.8	0.8 (5)	8	1.1	1.0	8
Electricity (GJ)	-1.0	-0.5 (-3)	-8	2.3	1.2 (8)	12	2.8	1.3	11
Co-generation heat & power (GJ)	1.6	0.7 (5)	12	5.2	2.5 (16)	24	5.8	2.5	20
Market pulp (t)	191	5.3 (34)	84	252	7.0 (45)	69			
Newsprint (t)	186	12 (75)	185	214	13 (86)	132			
LWC[1)] paper (t)	449	34 (220)	331	472	35 (230)	348			
Particleboard (m^3)	169	18 (120)	283	185	20 (130)	193			
Sawn lumber (m^3)	222	17 (110)	267						
Sawn lumber + particleboard (m^3)	318	24 (160)	383						
Glued laminated beams (m^3)	1010	63 (400)	990						
Glued laminated beams + particleboard (m^3)	1140	71 (460)	1120						

[1)]LWC … light weight coated paper
(A) …. Units of biomass input are GJ lower heating value for all 3 raw materials. Input units of m^3 ub (under bark) are also shown in parentheses for sawlogs and pulpwood

Table 4.5.3 Total value added by the production of various products from different materials (sawlogs, pulpwood, forest residues) expressed by different measures (Sahtre and Gustavsson, 2009)[126]

4.5.3 Strengths and challenges within the wood sector

From a circular economy perspective there are several strengths of the wood value system, which have come to the fore in the previous sections of this report:

- The high use of locally produced wood. In the EU, almost all the roundwood harvested is also used within the EU.
- The cascading set-up of the sector: almost all by-streams of wood production and manufacturing, e.g. various by-products of sawmills and woodworking industry, are used within wood-based industrial processes.
- The high recycling rate of the paper and pulp industry.

There are a number of challenges that will cause structural changes in the forest-based sectors and industries:

- Increasing demand for wood pellets
  The National Renewable Energy Action Plans, formulated by the EU-Member States to meet the overall 20% 2020 renewable energy target strongly rely on the use of biomass for heating, cooling and electricity. In sum, the use of biomass would supply

[126] Sathre R, Gustavsson L (2009). Process-based analysis of added value in forest product industries. *Forest policy and economics. 11*, 65- 75, as published in: Lenzinger Berichte 87.

about 42% of the renewables needed to meet the target, but this is equivalent to today's total wood harvest in the EU[127]. The biomass is mainly delivered in the form of wood pellets. The policy-induced increased demand for wood pellets has increased the production by 10 times over the past ten years. In 2012, the FAO published the first ever data on wood pellets: "In 2012 global production of wood pellets amounted to 19 million tonnes with about half of this (9.3 million tonnes) traded internationally, compared to only 2 million tonnes a decade ago. Europe and North America account for almost the entire global production (66 and 31 per cent respectively) and consumption of pellets (80 and 17 per cent respectively)."[128]

- Increasing competition from BRIC-countries
  In absolute figures, EU forest production (and Northern American) has gone down, as well as its relative share compared to Asia. According to the Forest Research Institute, it is unclear whether this is temporary, caused by the economic crisis or, structural.

- Challenges European forest-based sectors
  The ecosystem services delivered by forests are limited by definition, due to limited availability of land for forestry and the production time. At the same time, the demand for forest products is rapidly rising. The rise of the forest production in other parts of the world and a declining demand for traditional forest products as printing paper may trigger the forest sector to focus more strongly on the rapidly growing bioeconomy.

- Lack of research & innovation
  Only a hand full of researchers, less than fifty, address the forest-based markets and the future of the sector; the European Forest Institute calls it "a no-man's-land in research". Especially with the transition towards the bio-based economy, the biggest ever structural changes are expected to take place within the sector, requiring more knowledge, research and innovation.[129]

- Fragmented institutional structure
  The institutional structure of the forestry sector is not supportive of innovation. In a 2004 EU report on the forestry wood chain, it is stated that the despite the large size and diversity of the sector, the sector is fragmented and has few big companies. The profitability of the forestry sector and growth rates are low. A possible explanation can be found in the management structure: forestry and forest management are embedded within historically grown institutional settings. About 40% of the forests in the EU is publicly owned, around 60% are privately owned, often by families, and small size[130]. There are about 3 million forest owners in the EU[131].

In response to the weak institutional R&D structure and the upcoming challenges from the growing attention for the bioeconomy and the market demand for biomass as renewable energy source, the sector has started to organise itself with several platforms and institutes. For example. the Forest-based sector Technology Platform has been established by various

[127] https://ec.europa.eu/eip/raw-materials/en/content/enhancing-cascade-use-wood-integrating-intensified-mobilisation-forest-resources (Retrieved September, 2015).
[128] http://www.fao.org/news/story/en/item/210972/icode/ FAO, December 18, 2013. (Retrieved August, 2015).
[129] http://www.efi.int/files/attachments/publications/efi_wsctu_6_2014.pdf (Retrieved September, 2015).
[130] file:///H:/Circular%20Products%20Initiative/KINA21349ENC_002.pdf (September, 2015).
[131] http://ec.europa.eu/agriculture/forest/strategy/staff-working-doc_en.pdf (September, 2015).

forest-wood related branch organizations aiming to form a common knowledge base on wood resources, especially in the light of the rise of the biomass market. In the past decade, this has lead to several studies focusing, amongst others, on whether there would be enough wood supply in the EU[132]. It is estimated that a 30% increase of EU harvest rate is expected by 2020 compared to 2010. However, in the policy document in which this is reported it is also stated that Member States adopt different definitions of timber stocks and other forestry related reporting data[133]. Also other factors influence the harvesting potential, such as accessibility, speed of growth and the policy status of the forest: about 50% of all Natura2000 land is forest, about 23% of all forest land has a Natura2000 status[134].
With respect to forest-based biomass, the EU sees a potential for especially rural communities to create sustainable jobs and diversify income. The EU Biomass Action Plan expects that wood based energy will rise from 5% of the 2010 total energy supply to 10% of gross final energy consumption by 2020.[135]

4.5.4 EU policies

Member States all have national forest policies which have been formulated within a clearly defined framework of established ownership rights and with a long history of national and regional laws and regulations based on long term planning.[136] The EU Treaties do not intend or provide in the development of a common forest policy. However, there is a long history of EU measures supporting certain forest-related activities. Coordination of these measures and Member State policies takes place within the Standing Forestry Committee. The policies and measures formulated by this Committee mostly had to do with sustainable forest management, taking into account the multifunctional role of forests (provision of wood, fuel, shelter, food and water, security, employment, sustaining species and biodiversity) and the vital role of forests to local economies and the global environmental well-being. In 1998, the EU Forestry Strategy was adopted, putting forward the principles for sustainable forestry.[137] The Strategy emphasized that "the responsibility for forest policy lies with the Member States, the EU can contribute to the implementation of sustainable forest management through EU policies (subsidiarity, shared responsibility).

In 2005 a review of the Strategy led to the conclusion that the strategy was based on the right principles and addressed the right topics, but also that that a more coherent and pro-active approach was needed at EU-level. In 2006 the European Commission presented the Forest Action Plan. From an evaluation of the Forest Action Plan (2013), reported in the 'Commission Staff Working Document accompanying the EC Communication on A new EU Forest Strategy', it can be concluded that the Forest Action Plan was useful to some extent. It helped to Member States in the formulation and implementation of the national forest policies, but it was also emphasized that these policies were often of a voluntary character, lacking power to exert influence on a European level. Furthermore, there was still no shared vision on forestry, nor were there clear commitments and targets on which the Member States should report to the EU. The sector's response to developments in other policy areas seriously affecting forestry, such as climate change and energy, therefore remains weak and inconsistent.[138]

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132 E.g. https://ec.europa.eu/research/agriculture/pdf/forestry_wood_chain_eu_rtd_impact_1998-2004.pdf (August, 2015), http://www.egger.com/downloads/bildarchiv/187000/1_187099_DV_Real-potential-changes-growth_EN.pdf (August, 2015).

133 http://ec.europa.eu/agriculture/forest/strategy/staff-working-doc_en.pdf (September, 2015).

134 http://ec.europa.eu/agriculture/forest/strategy/staff-working-doc_en.pdf (September, 2015).

135 http://ec.europa.eu/agriculture/forest/strategy/staff-working-doc_en.pdf (September, 2015).

136 http://ec.europa.eu/environment/forests/home_en.htm (September, 2015).

137 http://ec.europa.eu/agriculture/forest/1998-strategy-2006-action-plan/brochure-2003_en.pdf (September, 2015).

138 http://ec.europa.eu/agriculture/forest/strategy/staff-working-doc_en.pdf (page 8), (September, 2015).

Important financing schemes for the forestry sector are RD Regulation. In addition, LIFE+ provides support for nature protection, forest information needs; cohesion and structural funds support regional development projects; H2020 and the European Innovation Partnerships (one on agriculture and one on raw materials) stimulate research and innovation actions[139].

Forests are affected by many sectoral policies, at first from an environmental and biodiversity point of view and more recently from a climate change and energy policy point of view[140]. However, policy integration, or the coordination with other policy domains, is still a key issue in which more progress can be made, according to the evaluation of the EU Forest Strategy.[141]

Illegal logging is another important EU policy focus, with the EU being a critical export market for wood. The Forest Law Enforcement, Governance and Trade Action Plan (FLEGT) has been adopted in 2003. It includes the EU Timber Regulation (EUTR), which has been adopted in 2010 and has been applied in all Member States in 2013, and the Voluntary Partnership Agreements between exporting countries and the EU. Certification plays an important role in the monitoring and compliance with the EUTR: wood carrying a FLEGT licence or a CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) permit are considered to comply[142]. Another scheme, adopted by 25 countries, aiming to protect forests is the OECD Scheme for the Control of Forest Reproductive Material Moving in International Trade. Amongst the 25 countries that have adopted the scheme there are also tropical countries, which aim to exchange seed for reforestation purposes.

The combat against illegal logging and deforestation and the fostering of sustainable forest management also takes place in various international arenas in which the EU also takes part. The United Nations Forum on Forests with its non-legally binding instruments on forests is perhaps the most prominent one, which again are of a framework character aiming to support national actions and international cooperation.

Besides these forest and forest products aimed policies there are EU policies of influence on specific wood products value chains. For example, within the furniture industry, there are several Directives on consumer information, obliging the producer to give information on materials used, risks involved, and main characteristics of the product.

4.5.5 Strengths, weaknesses and future opportunities for EU policies

The following strengths can be identified for EU policies with regards to wood products and wood processing. By focusing on forests and forest services, the policy attention focuses on the raw material supply and production. The aim is to safeguard this supply for the future and to balance the demands for the various services that are becoming more strenuous and conflicting. The EU Timber Regulation is highly important to reduce the market opportunities for illegally logged wood from other, non-EU, countries. For example, the paper and pulp industry expect their already high percentages of reuse and recycling of by-products and pulp to go up in the coming years as a result of the regulation.

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139 http://ec.europa.eu/agriculture/forest/strategy/staff-working-doc_en.pdf (September, 2015).
140 http://ec.europa.eu/environment/eutr2013 (September, 2015).
141 http://ec.europa.eu/agriculture/forest/strategy/staff-working-doc_en.pdf (September, 2015).
142 http://ec.europa.eu/environment/eutr2013/_static/files/press-briefings/eu-timber-regulation-media-briefing_v01_en.pdf (September, 2015).

Weaknesses of the EU policies seem to lie in the strong focus on forestry. In the staff working document explaining the 2013 Communication on the new EU forest strategy for forests and the forest-based sector it is mentioned that cascading should be a basic principle for all use of wood. However, within the Strategy there are no clear regulatory actions on the cascading use. This could be explained due to the fact that the cascading use of wood requires activities further down the wood value chain, beyond the phase of preserving and the sustainable use of the resource base. Particular actions and references to actions within other policy domains are absent. Within several wood-based value chains, there are policies that contribute to cascading. However, the cascading is especially under pressure due to the competition with non-EU wood-producing countries with lower wages, lower energy prices and less strict responsibility requirements[143]. EU policies like the Forest Strategy do identify the problem, and emphasize that it will most likely increase in the near future, but do not take much action on this. The market pull for biomass for energy production has become very strong, also under influence of the EU Directive on Renewable Electricity and the EU Biomass Directive. However, within these policy fields there is little attention (yet) to the conflicts that the policy may create with regards other values. As far as there is attention, it is especially focused on the competing claims on land use and crops for food.

4.5.6 Long term policy considerations

From a circular product point of view, the most pressing challenge within the wood sector is the competing use of wood for energy production and for the production of other (semi-finished) products. Traditional wood-based value chains have evolved over centuries and uses cascading principles whenever possible to save money, energy and virgin raw materials. This has given the industry an overall positive performance in terms of circularity. Within the different value chains, product and resource oriented policies have further pushed the sector to the reuse and recycling of materials and the saving of energy, water and other resources needed for production. However, these efforts and achievements seem to be of less importance within the drastic change of the market conditions. The higher demand for biomass strongly competes with the demand of wood for the traditional products. Especially within the EU this leads to the situation in which the locally grown wood is more and more used in a low quality for energy production with no recycling opportunities. At the same time there is the concern that the higher demand for wood will be filled in with imported, illegally logged wood. The enforcement capacity of the EU beyond its boundaries depends on soft regulations in the form of certification schemes and voluntary, bilateral agreements between countries and the EU. Also the highly fragmented ownership structure of forests complicates the opportunity to control and enforce agreements on sustainable forestry.

Even though the linkages between the policy domains of forestry based products and renewable energy are clear to policy makers from both domains, and even indicated in policy documents, there are few attempts to address the possible tensions and trade-offs between these domains. Focusing on improvement of the circularity of the wood-based products would be of less significance with the strong rise of short-cycled use of wood for energy production.

[143] http://cepi-sustainability.eu/uploads/short_sustainability2013.pdf (September, 2015); Centre for industrial studies (2014). *The EU furniture market situation and a possible furniture products initiative. Executive Summary.* Report to the EC DG Enterprise and Industry within framework contract /ENTR/008/006. Brussels.

5 Mechanisms accelerating and slowing down change

5.1 Introduction

The "route from Brussels to member states is not a straight line" (Caporaso, 2007, 30[144]). EU policies have to find their way to the MS policies through a myriad of national and local cultures, institutions and existing policies and practices which all influence policy implementation. This chapter addresses how processes initiated at EU-level trickle down to domestic policy levels and vice-versa, via so-called processes of downloading and uploading, and what drivers and barriers there are for these processes. To analyse these processes in a coherent way, we focus on three mechanisms that have proven to support accelerated transformation, i.e. change with stable, long-term effects. (Jänicke, 2015)[145].

- Interactive circles of policy-induced market growth and innovation, including policy feedback leading to more ambitious and more effective policies and implementation mechanisms. (section 2)
- Reinforced diffusion from pioneer countries or industries, in which lead markets and lesson drawing on policy implementation (peer-to-peer learning). (section 3)
- Multi-level governance, in which the horizontal diffusion of technologies, best practices and lessons is vertically reinforced (section 4).

After a short explanation of the mechanism concerned, each section focuses on the drivers and barriers identified in general knowledge of policy instruments (chapter 2) and as identified in the policies and instruments dealing with circular economy (chapter 3) and in the cases (chapter 4).

5.2 Policy-led market growth and innovation

Public policy usually plays a strong role in promoting public values. Also with the ambition to transform our economy to a circular economy public policy plays a role in setting ambitions and in changing the institutional context and the incentive structures, which guide actor behaviour. Jänicke, following the self-reinforcing mechanisms in economy identified by Arthur (1988) and in systems of innovation literature (e.g. Watanabe et al., 2000, Hekkert et al., 2007, Bergek et al., 2008[146]) has added a policy dimension to this economic perspective. The mechanism at play in economic development, with market growth and innovation as mutually reinforcing processes, can be completed by adding the dynamics of the policy processes, from agenda-setting, policy formulation, policy implementation, to policy evaluation and policy revision. Figure 5.1 presents the interaction between technological innovation, market growth and public policy. Innovations influence the range of policy options and policy ambition levels. Policies in turn can influence the market conditions for these

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[144] Caporaso, J., 2007. The Three Worlds of Regional Integration Theory, in Graziano, P., Vink, M. (Eds.), *Europeanization: New Research Agendas*, Palgrave Macmillan, New York, 23-34.

[145] Janicke, Martin (2015). Horizontal and Vertical Reinforcement in Global Climate Governance. *Energies*, *8*(6), 5782-5799; doi:10.3390/en8065782

[146] Watanabe, C., Wakabayashi, K., & Miyazawa, T. (2000). Industrial Dynamism and the Creation of a "Virtuous Cycle" between R&D, Market Growth and Price Reduction. The Case of Photovoltaic Power Generation (PV) Development in Japan. *Technovation*, *20*, 225–245.
Hekkert, M.P., Suurs, R.A.A., Negro, S.O., Kuhlmann, S., & Smits, R.E.H.M. (2007). Functions of innovation systems: A new approach for analyzing technological change. *Technol. Forecast. Soc. Change*, *74*, 413–432.
Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., & Rickne, A. (2008). Analyzing the functional dynamics of technical innovation systems. A scheme of analysis. *Res. Policy*, *37*, 407–429.

innovations, contributing to market growth, which in turn fosters the market pull for innovations.

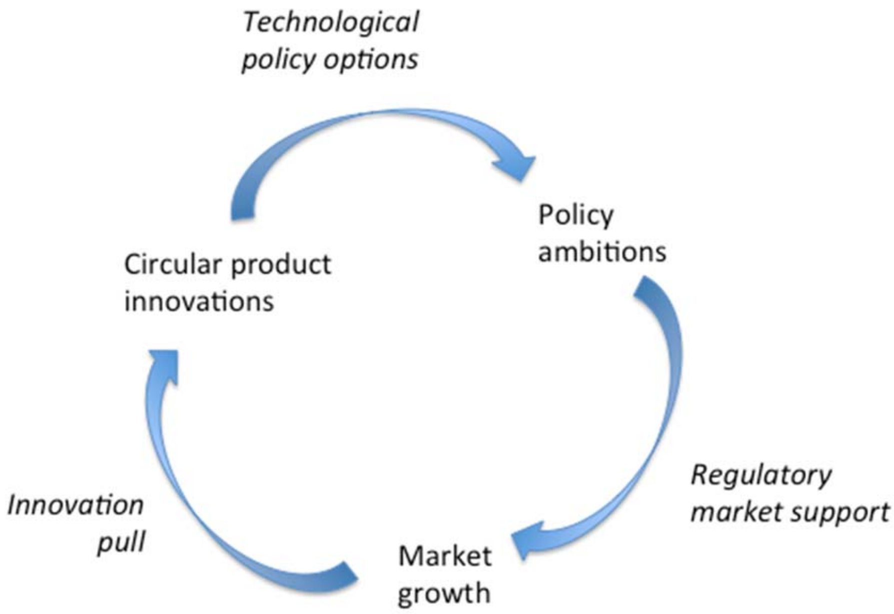

Figure 5.1 Reinforcing mechanism of technological innovation, market growth and public policy

From the perspective of this reinforcing mechanism, the following factors that can be a driver and/or a barrier for policy implementation and policy change can be identified.

5.2.1 Technological support structure

There is a wide variety amongst member states on presence of infrastructures (e.g. shortage or overcapacity of landfills, incinerators, return routes) influencing the business models for innovation. The support structure also seems related to the industry set-up. Especially industries with a highly fragmented structure and a dominance of SME's seem to have less coordinating, financing or lobbying capacities to provide for such infrastructures.

5.2.2 Technological standards and norms

Technological standards and norms for performance of products, product components, and for end-of-life processing are key to many EU policies. These standards and norms are based on negotiated knowledge. Industry has a clear knowledge advantage over government, and knows best how to comply at minimum costs. Government therefore has to rely on industry for formulating these norms and standards. Industry has a stake to take up this role since they have high interests that are to be affected by these standards and norms. There is always a play going on between government and industry in these processes of standard setting and compliance, in which government must push for higher ambitions and compliance. In all the cases we have witnessed strategy documents by sector organizations that emphasize their performance in relation to the national and international policy goals. These documents often include action plans or road maps stating how compliance or achievement can be further improved.

Standards and norms have a high lock-in effect. Partly this is related to risk assessment and insurance to cover the risks. Standards and norms also influence the innovation path and are reflected in the production facilities and assets and channels for distribution and return.

Also, standards and norms are usually very precise; they concern a particular component, material, or process, usually in one part of a chain. There are high sunk costs in production facilities and processes to comply with these standards and norms. Changes of standards and norms within one part of the chain will have upwards and downwards effects, calling for changes in these other parts of the chain as well. Non-incremental change of standards and norms is therefore difficult and meets high resistance.

Within the field of EEE, the chain structure is more flexible, due to the contract manufacturing of entire products by brand firms. For new products, there may be more openings to renegotiate standards and norms. However, when these negotiations take place with the brand firm, this does not automatically lead to compliance commitment by the manufacturers, who often are located at a long distance, under different rule regimes.

5.2.3 Rebound effect

As with many efficiency increasing technologies, the gained efficiency on the level of individual product performance is outweighed by the lost efficiency on the level of the overall product lifecycle, taking into account aspects such as the use, lifetime and composition of the product. In the WEEE case we have seen that improved efficiency was annulled by the decreased lifetime of the product.

5.2.4 Market demand for products

The cases show that there are initial pulls and pushes for the market, in terms of consumer demand, corporate social responsibility, and (local) government policy to produce circular products. Policies can reinforce this by raising ambitions and creating more favourable market structures. Especially in cases where there is already market, which needs to be stimulated in a certain direction, there is a good opportunity to intervene with regulations. For example, the reuse of recycled materials can be increased by a regulatory demand for a higher percentage of recycled materials to be included in product manufacturing. However, in cases where there is no demand for reuse or recycled materials, it will become difficult if not impossible to establish one. Regulations could then focus on stimulating product innovation to redesign the product from the perspective of the value of the end-of-life product and its components.

5.2.5 Changing consumer attitudes (sharing / performance economy)

Consumer demand is another strong, natural incentive for circularity. The procurement policies of governments, for example in the building materials case, have already shown that the use of consumer demand power can make a difference to producers. Recently, there is a trend towards a consumer preference for sharing instead of ownership. If this trend continues, a tipping point might be reached that can force a breakthrough in the circle of blame, in which stakeholders at different parts of the chain claim that they could change if only the other parts of the chain would ask them to. Actors point to their dependent position in the chain and use the absence of demand for sustainability upstream and downstream to justify their lack of initiative for sustainability.

5.3 Reinforced diffusion

The second reinforcing mechanism identified by Jänicke (2015) concerns the enforced diffusion, which we rather term as reinforced diffusion to prevent misunderstanding since diffusion cannot be enforced. This mechanism is concerned with the push and pull factors for diffusion of innovations. Countries, but also industries can play a lead role in certain fields of innovation and market development. Also the EU is always looking for sectors in which they can take up a lead market role. There are already some lead markets identified where the EU is taking up this role. Circularity could be added as a major strength to these lead markets. Lead markets not only push the diffusion of innovation in other countries, they also create a pull from these countries by raising curiosity of these countries for the secret of their success. In response to the successful diffusion, countries often aim to draw lessons. Lesson drawing[147] is therefore an important support mechanism for stimulating and reinforcing diffusion, lessons being learned about setting the regulatory conditions right for innovation and diffusion, as well as peer to peer learning about implementation and the support mechanisms. The wood case in this report illustrates the potential strength of policy to push innovation and create a new (lead) market. With the renewable energy package and directives in the field of renewable electricity and biomass the EU gave a strong impetus to a new market for wood-based biomass, competing with existing markets.

5.3.1 Regulatory differences between Member States

The difficulty with the EU promoting a lead market is that even though there is a single European market, there are still considerable differences between countries with respect to regulation. Especially with sectors that have a longstanding history within the Member States, such as the forestry-based industries, it is difficult for the EU to formulate common policies of a non-voluntary character. They interfere with national regulatory frameworks that have long been in place.

5.3.2 Freedom of choice regarding support mechanisms

Implementation support mechanisms differ per Member State. Often Member States experiment with different implementation mechanisms, in search for instruments that fit their domestic conditions and preferences. Usually, during the policy formulation process, Member States lobby for having their own mechanism to support implementation to be included in the regulation, which will give them a strategic advantage over other countries and will reduce costs for transposition and compliance. However, often, there are deliberately no support mechanisms formulated, because every Member State should be allowed to use those instruments and tools best fits domestic conditions. In case of new innovations and regulations, experimentation with variety of support mechanisms in the various Member States may lead to very different diffusion and adoption pathways, as happened in the case of the Renewable Electricity Directive. In this case, the Member States experimented with different kinds of implementation mechanisms. After years, more and more countries started to copy the German support mechanism: the feed-in tariff which provided a secure return on investments over a long term, providing an enormous pull factor for solar technology. Within the cases, we have seen the rise of labelling and certification schemes as most effective regulatory instrument, both on a voluntary and non-voluntary basis.

5.3.3 Harmonisation challenge

Member States are always struggling to transpose the EU policy to their domestic rule regime in a cost-effective way that matches best their existing institutions and practices. This also contributes to the high variety of policy implementation practices. To deal with the implementation issue, dozens of committees and agencies have been established in the

[147] Rose, R. (2004). *Learning from comparative public policy: A practical guide*. Routledge.

past[148]. Aim of these, often informal organisations is to attune and possibly harmonize implementation practices and support mechanisms. These organisations do not have a formal, democratically legitimized position but they do play a big role in the development of a joint understanding of the possible effects of a policy and how best to achieve these. Within the highly fragmented forestry sector there have been attempts to harmonize Member State policies by setting up joint organisations for research and policymaking on an EU-level; however, without organised and supportive 'home markets' these organisations did not succeed to achieve the ambitions stated.

5.3.4 Compliance culture

In different Member States there is a different culture of compliance. Especially with regards to processes of labelling and certification (for example of products or of recycled materials) there needs to be a basis of trust and certain level of compliance. Within many committees and agencies the EU aims to coordinate different compliance between the Member States. When there are strongly institutionalised national sectors, it is difficult to establish joint action. For example, the cases showed that in the field of reporting and measuring Member States use different statistical data, based on different definitions. Also between different value chains within a value system there may be differences in compliance cultures. The reuse of products between different (parts) of value chains may be hampered because of this. Processes of norm setting and standardisation can be considered a response to this, but these are strong institutions, which slow down change.

5.4 Multi-level governance: vertical reinforcement of horizontal diffusion

The third mechanism to reinforce innovation and diffusion results from the multiple levels of governance involved in directing, influencing and guiding of innovation and market growth. "The broad variety of possible vertical and horizontal interactions makes it possible that innovation takes place at different parts of the governance system" (Jänicke, 2015).

Multi-level governance can stimulate vertical and horizontal learning at all levels of the global system. This has become particularly relevant regarding horizontal dynamics on the sub-national level being induced by higher levels. For example, in the WEEE case and the building materials case, local authorities turned out to be very important driving forces behind demonstration projects, development of best practices or the development of local institutional and technological infrastructures for circularity and related ambitions.

The multi-level governance refers to all forms of governance, executed by both public and private organisations. For example, at the international, global level there are public organisations active as the United Nations, with the International Resource Panel, but also private organisations the Ellen MacArthur Foundation and the World Business Council for Sustainable Development, but also industrial umbrella organisations aiming to represent industry's interests. At the domestic and local levels other organisations can be identified playing a role in governance of market developments and innovation. Horizontal and vertical interaction between organisations active at these levels and cross-overs between public and private organisations can contribute to the creation of a wide variety of push and pull factors for circularity, reinforcing each other and creating governance opportunities that go beyond the formal spheres of influence.

[148] Groenleer, M. (2009). *The autonomy of European Union agencies: A comparative study of institutional development*. Eburon Uitgeverij BV.

5.4.1 Lesson drawing from pioneers is possible at all levels

Pioneers always play an important role in processes of innovation. Lesson drawing can take place horizontally, by copying the lessons learned, or vertically, by the up scaling of initiatives. The lesson drawing can take place within value chains or between value chains, and within countries and between countries.

Also with regards to policy making lessons can be drawn horizontally and vertically. Especially within the context of a decentralising government, local governments search more and more for policies that work. They often do so in an experimental or living lab-like setting. The up scaling of local experiments or small-scale initiatives can take place by enlarging these initiatives, and by including other government levels as well, or by copying the initiatives many times, keeping the small scale character. For example, the green construction certification schemes have started on a small scale, on a voluntary basis. They have gained importance within countries and have been copied in many countries. Also they have become intertwined with non-voluntary regulation, for example in the field of fiscal regulation.

5.4.2 Mixed motives

Circularity is triggered by mixed motives. Actors at different levels, in different roles are motivated to contribute to a circular economy for different reasons. Traditional policy instruments as discussed in previous chapters tend to assume governed actors as ‘homo economicus’, displaying behaviour to maximize utility and minimize regret.

The multi-level governance setting allows policy makers at different levels to address their target group in a way that suits them. For example, mayors who want their municipality to become ‘a circular hotspot’ often are less interested in detailed and highly technical discussions about performance of secondary materials. Attuning policies to the different motives that actors may have for contributing to circularity could lead to a different array of policies and incentives.

5.4.3 (Perverse) substitution

Intervening in complex systems as value chains and value systems will always lead to unexpected effects. Closing loops may lead to a new product which competes with other products, or may invoke a demand which competes with existing demands (e.g. biofuels that compete with food production; the collection of plastic waste that reduces the quality of energy produced in incineration plants; the recycling of concrete for building construction which reduces the availability of -cheap- recycled concrete for road construction). When implementing interventions, the opportunity to become aware of such substituting effects will have to be organised, for example in the form of monitoring and evaluation. When the effects are felt within other parts of the value chain, in other value chains or in entirely different sectors, markets or countries, it will be difficult to identify or respond to these effects by the stakeholders that have initiated the intervention.

5.4.4 Feasibility of coordination in the chain

Integration of chains cannot take place without a regulatory structure stipulating appropriate behaviour, e.g. regarding information exchange and transparency, joint procurement, accounting systems, etc. In reality, it turns out to be very difficult to achieve this, due to competing goals and interests of actors operating in the chain. Closing loops may require reconfiguration of the chain and power balance within the chain, calling for institutional changes, which are not supported by incumbent players whose position is under pressure. In turn, chains that have been quite well organized, may be reluctant to change – they have invested a lot to make the chain more efficient.

5.4.5 Blind spots

Lastly, the multi-level governance setting can contribute to the reinforcement of diffusion, but can also contribute to blind spots. For example, the concept of organised irresponsibility refers to the blind spots for the overall effects of a chain, when regulatory frameworks – initiated by many different public and private organisations - are focused and attuned on the different parts of the chain, making sure that each part of the chain contributes to its particular sustainability targets and requirements[149]. For example, the cases, WEEE being the most extreme one, shows that there are no policies that address the miniaturization and the shortening of the economic lifespan of consumer electronics, but this remains an unidentified area in policymaking.

5.5 Conclusions on accelerating and slowing down mechanisms

This chapter has shown the many ways in which public policy ‘matters’. Public policies, in all sorts of forms, can contribute to the acceleration of the development of circular products and markets for circular products. With regulatory instruments, markets for circular products can be created or stimulated. With technological support structures, the conditions for circularity, including innovations in products and chains enabling and facilitating reuse and recycling, are being fostered or created. By making use of the variety of ways in which governments and governing organisations at different administrative levels and spatial scales can influence the decisions of producers and consumers, a hybrid of push and pull factors for product innovation and market development is being created. However, despite these accelerators there are also mechanisms that slow down developments, ranging from the rebound effect to the disrupting interference with other markets which impact the sustainability of those markets.

[149] van Bueren, E. M., van Bueren, E. T. L., & van der Zijpp, A. J. (2014). Understanding wicked problems and organized irresponsibility: challenges for governing the sustainable intensification of chicken meat production. *Current Opinion in Environmental Sustainability*, *8*, 1-14.

6 Conclusion and recommendations

This report underlines the Circular Economy, and policies to further it, are not an ideal for the far future; the Circular Economy has arrived and will become stronger over the coming years and decades. EU policy has been (and is) pivotal in establishing this Circular Economy in interaction with enterprises and markets. Even though in EU environmental policy themes such as energy, climate and environmental health dominate, on a wide range of products, materials and industries EU policies have been implemented in member states with varying degrees of success. We already observed that administrative instruments dominate, but these are often complemented by policy mixes of voluntary and compulsory and of economic, administrative and communicative instruments. Notwithstanding these successes, which appear underemphasized in the current perception of the Circular Economy, we identify two significant issues for effective EU policies to make the full transition to a circular economy.

6.1 Present EU policies: strengths and issues

6.1.1 Issue: fragmentation and prioritising

Even if each individual policy instrument may be well motivated and effective, the myriad of instruments that evolved over the decades is fragmented. The EU instruments are also ‘children of their time’: they reflect historic priorities, which might not always match current priorities for a circular future. This fragmentation and lack of coherent prioritisation has a number of aspects, amongst which:

1. There is a significant difference in level of circularity between member states. Bringing all EU member states to ‘best of class level’ is a priority.
2. Especially for biobased circularity (e.g. wood) there are potential negative effects on circularity from energy policies that urgently need addressing. Energy recovery is currently stimulated, rather than re-use or material recycling. In other fields, well designed material circularity can also reduce energy use.
3. We see quite some differences with regard to the extent that instruments cover the product life cycle. Even instruments that aim for an integral approach, often concentrate efforts on the waste stage. Particularly the design of products and business models needs an overhaul, if one wants to make a switch to circularity beyond materials recycling (i.e. life time extension, product and component re-use).
4. This fragmentation over the cycle of policies, mirrors the fragmented nature of many supply chains that cut through different industries, markets and geographical scales, greatly challenging integral design for circularity owing to power relations, inability to influence (or even understand) up-chain processes and the role of standards and norms.
5. The EU waste hierarchy prescribes priorities such as reducing and re-use before recycling and the Circular Economy philosophy in addition demands high purity or cascading loops. It seems however that most instruments still effectively stimulate re- and downcycling of materials, rather than explicitly addressing product or component re-use and refurbishing/remanufacturing. Where often it would be theoretically possible to design cascades, we see high-quality components and materials in one step downcycled to the lowest form of recycling possible.
6. There is a significant bias on circularity of the largest volumes of materials that constitute products, rather than on the circularity (or avoidance) of the most scarce or critical materials within these products.
7. Even for product types that have public or private systems in place to provide circularity to products, a large percentage of products never enter these systems and directly move

to landfill or incineration; or products take a short-cut to low quality applications, where more added value is possible by first cascading through high quality applications.

6.1.2 Issue: meeting high ambitions and countering averse trends

For the short term, thus ample opportunity exists for enterprises to better exploit the existing opportunities and for the EU (and other policymakers) to increase these opportunities by optimising their policy mixes and so gradually progressing towards circularity. But as the urgency and ambitions for larger, accelerated leaps towards circularity increases more fundamental long term challenges loom, especially as we also concluded that there are averse long term trends in many industries, towards linearity, such as shortening life spans of products. It can be questioned if such ‘megatrends’ can be reversed by simply strengthening and expanding the current EU conventional policy mix. In the cases we found such instruments to be effective for low hanging fruit, but less effective for fundamental breakthroughs, especially if we take into consideration that policy development and implementation is not a straightforward, analytical activity, but a complex interplay of economic, psychological, political, demand, market and cultural factors. Integral design, moving from recycling to re-use and re-manufacturing, might not be possible without innovations that might be perceived as disruptive by incumbent actors.

6.2 What the EU can do: towards a Circular Products Initiative

6.2.1 Enhance existing instruments which provides opportunities now

Further development of EU policy through a ‘Circular Products Initiative’ has most success if such an initiative is not a stand-alone activity but integrates and strengthens the myriad of policies already implemented and in development, in line with the identified challenges. Plenty short-term opportunities already exist. These opportunities could be supported by enhancing various existing EU product policies, as suggested in the table below.

The current image of the Circular Economy emphasizes entirely new products, supply chains and business models. While it is necessary to start working on such innovations now for the medium and long term, plenty short-term opportunities already exist, which many actors might not yet recognise. These opportunities could be supported by enhancing various existing EU product policies, as suggested in the table above.

Several EU policy instruments in that table do not directly aim to promote the circular economy (e.g. REACH, RoHS). These instruments are nevertheless included in the table because they can indirectly contribute to circularity and sometimes contain circular principles (such as Extended Producer Responsibility).

Table of EU policy instruments & short term actions

Life cycle stage	Example of current EU instruments	Typical products and materials	Typical sustainability topics	Potential enhancement (short term)
Resources	Critical raw material list	Minerals and metals	Resource scarcity	Introduce quality standards for recycling of critical raw materials.
Manufacturing and design	Environmental / product liability directive Restriction of Hazardous Substances (RoHS) Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Ecodesign directive	Electrical Equipment, chemicals, buildings, vehicles, manufactured goods	Energy consumption of the product, hazardous chemicals, sustainable innovation	Enhance Extended Producer Responsibility, truly along the full life cycle rather than just the use stage Enhance the Ecodesign directive to a broader set of product groups as the 40+ currently covered, and to other environmental aspects as energy efficiency. Include criteria for circular product design and circular business models Introduce voluntary agreements ('Green Deals') between industry and EU to stimulate sustainability initiatives throughout the sector. Identify and award frontrunners and bottom-up initiatives.
Distribution and retail	Energy labelling Eco-labels Organic labels	Electrical equipment and food	Energy and pesticides	Enhance labeling instruments to a 'product passport' system
Consumer behavior	Green Public Procurement (Energy labelling)*		Not topic specific	Enhance Green public procurement to a broader set of products, and award circular product design and circular business models
Post-consumer ("waste" phase)	Waste directive** WEEE directive** Packaging directive EU End of life vehicles directive Landfill regulation Shipment of waste regulation Extended Producer Responsibility**	General and household waste, electrical equipment, vehicles	Third world waste dumping, recycling, health and safety, pollution, resource scarcity	Move away from recycling targets on mass basis - set specific targets for small mass flows of critical or harmful materials, Set also targets for re-use and remanufacturing. Implement measures to allow for improved identification of illegal waste shipments.

**) Energy, eco- and organic labels are at the intersect of retail and consumer behavior*
***) These instruments have a focus in a certain link in the product chain, but also exhibit more integral characteristics*

6.2.2 Address systemic issues in the current policy mix

Promoting the circular economy however also needs more fundamental adjustments to address systemic problems. We suggest to address the following issues on the medium to long term:

Reduce policy fragmentation and intervene at the in- and output of linear chains.

Reducing fragmentation requires more general and less specific instruments, as it is infeasible to develop coordinated instruments for each type of product. We thus need a shift from a policy mix that primarily differentiates between products (or industries), to differentiation between laggards and frontrunners, and policy mixes that combine different types of instruments. Logical intervention points for more general policies are the beginning and end of the product cycle (primary and secondary resources), where the complexity is less than at the level of thousands of different products. Recommendations for the use of instruments include:

a. Shift tax from labour to resources.

b. Stimulate the use of abundant materials and de-incentivize the use of critical materials, e.g. by tax differentiation.

c. Set limits to incineration and landfill of materials that can be re-used or recycled.

d. Further development of Extended Producer Responsibility beyond the use stage of products towards re-using and remanufacturing of products and product components and re-use and recycling of materials.

Improve prioritisation

For better prioritising, the identification of critical materials could be expanded upon by an ‘EIPRO study for circularity’ (EIPRO: Environmental Impact of Products) which products have the most potential for enhanced circularity? For which products (as in our report: clothing / textiles) have a high potential but are hardly addressed by policy instruments? Prioritise those products that have large inefficiencies in terms of waste production, low recycling rates, and high input of virgin materials. It is probably feasible to transfer the existing good examples to other, uncovered product groups. Other high potential product groups might be more challenging and require a new type of instrument. For these products, policies aimed at the design stage could be far more effective than measures aimed at improving opportunities for reuse and recycling.
Other recommendations for better integration and prioritisation are:

a. Minimize the use of instruments based on norms, standards and prescriptions, but use instruments based on goals and targets.

b. Organise a more balanced attention of policies and instruments over the full life cycle, instead of mainly addressing the waste stage.

c. Stimulate cross-industry dialogues over the entire supply chain and identify those parties that can take on a leadership role for cross-chain innovation towards circularity.

d. Use instruments that reward product life extension, product and component re-use rather than re-use per se.

e. Use instruments which give more focus on the recycling of scarce/critical materials, rather than setting targets on material recycling by volume.

f. Circular policies should be designed to take priority in policy and practice over energy policies, as the EU waste hierarchy prioritizes material recovery over energy recovery. For instance, recycling of biomass should prioritized over its use as (carbon neutral) energy carrier.

6.2.3 Explore a new generation of policy instruments to further fundamental breakthroughs

Lastly, the EU needs to move beyond the current emphasis on conventional policy instruments, existing instruments must be re-examined. We have to accept that major changes towards circularity imply a future, in which new business models run by new businesses will arise, and old business models run by existing businesses will die out. Existing firms will not in all cases be able to make this change. Relying on win-win solutions only hence will not result in fundamental breakthroughs.

True radical changes towards circularity are a form of creative destruction, in which also contextual factors and framework conditions must change. Such change usually takes a long period of time and ‘command and control’ approaches usually will not work. Indicative planning and developing ‘strategic intent’ with a process of learning by doing along the way are likely to be much more successful. Policy needs a broader system approach, instead of just looking at value chains of resource extraction, production, consumption and waste management which were central in the analysis above.

A delicate balance has to be maintained in engaging front runners and constructive actors in policy making, and more or less neglecting parties that are probably unable to make changes, and who hence may fight any intervention that is not in their interest. Inspiration for novel policy instruments supportive of fundamental breakthroughs can be found in fields like **innovation studies, transition management, strategic niche management, and social innovation**. Suggestions from these fields include:

1. Put pressure on the existing linear production regime. In this, an important role is to be played by the instruments already suggested in previous paragraphs, such as shifting taxation from labour to resources, landfill and incineration bans for re-usable and recyclable materials and product components, and awarding front runners via e.g. labelling and green public procurement.

2. Organise a process of ‘visioning’ and experimentation in specific value chains, particularly when it is not totally clear into which direction the change has to go.

3. Encourage and facilitate market-based actors and industry leaders, who interact in supply chains and within sectors, to create innovative ideas, and share best practices. Support flagship’ (niche) experiments with new practices and systems to provide stepping-stones for potential future new socio-technical constellations. Inspiring examples of resource-efficiency in sectors where resistance to change is high can help to legitimate stronger top-down policies.

4. Organise financial and technological support policies to reduce costs of long-term, high impact resource-efficiency improvements that currently are too expensive to implement.

5. Labelling and other environmental product information should be clear, correct, verifiable and relevant without misleading consumers. For a better understanding of labels by consumers it would be of importance to look into ways for harmonizing the world of labels in Europe. It would be interesting to identify options for making the

level of sustainability of products visible or readable in such a way that consumers can understand it in a blink of an eye and without any background information on specific environmental aspects or product related issues.

6. The current Ecodesign Directive requires the setting of benchmarks in each product specific implementing measure. Benchmarks should be used as the new minimum requirements for products after a certain period of time or when revising product-specific regulations. Benchmarks should address all relevant environmental aspects and become the motor of a policy that encourages a ‘race to the top’ of the best performing technologies. The use of long term benchmarks as ‘technology forcing standards’ containing long term requirements will support innovation.

7. Design plays a crucial role when moving towards a circular economy. The traditional design brief is product focused without much realisation to the restorative opportunity of the ecosystem through design itself. Circular design approach requires taking one step back before the actual design brief. The current model is about ‘regulation’ in a traditional sense: the directive aims to improve efficiency through minimising negative environmental impact, whereas the circular design approach is about maximising a positive, regenerative footprint. Circular design requires a move from product level to the systems level and from energy related products to all products and services as well as an effective approach to incentivise businesses to adapt their design strategies accordingly.

8. The polluter-pays-principal is currently reflected in the instrumentation of the Extended Producer Responsibility (EPR) but in such a way that EPR does not offer an environmental protection strategy aiming at a decreased total environmental impact from a product. The EPR should be delivering a strong mechanism for industries to continuously improve their products and processes. Linking it to the broader scope of Corporate Social Responsibility could be an option to strengthen the position of EPR on a strategic business level.