DYNAMIX

Decoupling growth from resource use and environmental impacts

Policy mixes fostering sustainable resource use

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DYNAMIX PROJECT PARNTERS

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1 The need for policy mixes to foster sustainable resource use[1]

Global consumption of material resources has seen marked increases in the last century, in particular since the 1950s (Krausmann et al. 2009; Schaffartzik et al. 2014; Steffen et al. 2011; Wiedmann et al. 2015). The use of resources, and in particular the production of bulk materials (e.g. steel, aluminium, cement and polymers), is responsible for a significant share of the energy demand and greenhouse gas (GHG) emissions of human society (Brown et al. 2012; IEA 2008). Transforming these materials into consumption goods, infrastructure, and housing also generates significant additional environmental impacts: degradation of a large share of ecosystems (MEA 2005) and ever increasing ecological footprint of human activities, which already in the year 2005 amounted to more than 1.4 planet Earths (Galli et al. 2012).

Global megatrends risk exacerbating the situation in the future and further challenge the likelihood and feasibility of transitioning to more sustainable resource use pathways. Rising global population and affluence levels, ever more widespread adoption of westernized lifestyles and production and consumption patterns will contribute to future increases in resource consumption, which is expected to reach approximately 140 billion tons of minerals, ores, fossil energy carriers and biomass by 2050, more than doubling from the 68 billion tons reported for 2009 (Fischer-Kowalski et al. 2011). Such resource use and associated environmental impacts contribute to (further) transgressing existing planetary boundaries (Steffen et al. 2015). Human activities are expected to require two planet Earths around 2030 (Moore et al. 2012) and fossil-fuel dominated energy use will increase by almost 80% by 2050 (van den Berg et al. 2011).

Although humanity is not likely to run out of material resources in the foreseeable future, the production rate of renewable materials is limited and the economic cost of producing non-renewable materials is likely to increase with time, particularly if material use continues to increase (Allwood et al. 2011). Increasing the efficiency in the use of material resources, therefore, is important to generate as much economic value and/or well-being and serve as many functions as possible with a given resource base. Furthermore, In addition, increasing resource use efficiency can counteract future supply risks for certain materials, e.g. for rare earth metals (Ekvall and Malmheden 2014), because the mineral reserves and/or mines are located at very few places in the world.

Hence, increasing efficiency in the use of material resources is important to steward our resource base and enable present and future generations to benefit from using resources sustainably, thus increasing the resilience of social-ecological systems and achieving a more sustainable economy in the long term. The use of material resources can be made more efficient through increased recycling, but also through increased material efficiency. The latter can include material-efficient production processes, material-lean products and systems, products with a long service life due to high quality and repairability, changes in consumption patterns from products to services, from owning to sharing, etc. (*ibid*.).

[1] This section is based on and adapted from Ekvall et al. (submitted).

Policy-making for resource efficiency is a complex and large-scale challenge. A single material is typically used in many different applications and sectors. Economic interlocking of streams of resources, semi-finished and finished goods a makes resource policy a policy field involving a multitude of interdependent actors in value chains that cross national boundaries and on markets that are often global. Taking into account the specific conditions of each application and each actor is hardly possible. And yet, failing to do so increases the risk that policy interventions shift the use of resources to other applications or regions of the world, rather than increasing resource efficiency. Furthermore, efficiency gains obtained from improving resource use efficiency may trigger greater consumption of the same good/service or of other goods and services, eventually backfiring and causing rebound effects (Binswanger 2011).

These complexities, the many functions that material resources serve, and the multitude of involved actors in multi-actor-systems calls for a more systemic approach to resource policy making. Such an approach would need to allow policy makers to account for the most important aspects and causal relations between relevant trends and drivers and their effects when designing policies. Furthermore, such an approach requires a very broad systems perspective in order to capture as much as possible the system's complexities.

Against this background, the DYNAMIX project ('DYNAmic policy MIXes for absolute decoupling of environmental impacts of EU resource use from economic growth', www.dynamix-project.eu) identifies policy mixes that support absolute decoupling of economic growth from resource use and its associated environmental impacts. These policy mixes are tested in qualitative and quantitative ex-ante assessments against

1. Their potential environmental effectiveness vis-à-vis the five key targets
   - consumption of virgin metals: -80 % compared to 2010 measured by RMC in the EU representing scarcity of metals and environmental impacts caused by extraction, refinement, processing and disposal of metals;
   - greenhouse gas emissions; 2 tonnes CO2-equivalent per capita and year (measured as footprint to reflect embedded emissions and as EU-internal emissions) representing climate change impacts of greenhouse gas emissions through energy use as well as agricultural and industrial processes;
   - consumption of arable land: zero net demand of non-EU arable land representing, as a rough approximation, impacts of biomass production on soil quality, water quality and biodiversity;
   - nutrients input: reducing nitrogen and phosphorus surpluses in the EU at the level best available technique can achieve representing impacts of agricultural production on marine and freshwater quality as well as soil quality;
   - freshwater use: no region should experience water scarcity representing impacts of resource use on freshwater availability (Umpfenbach 2013); and
2. Their potential side-effects in terms of socio-economic impacts, public acceptability and legal feasibility.

In order to identify promising policy mixes, we implemented a heuristic framework guiding our analyses and assessments.

2 DYNAMIX heuristic framework to policy mixes

2.1 Heuristic framework for policy mix design[2]

The DYNAMIX project has tested a systematic approach in developing policy mixes for fostering absolute decoupling in the EU by 2050. The procedure for developing the policy mix has been reflected upon and revised as part of the DYNAMIX project.

Policy-making for resource conservation and efficient use of material resources needs to apply a broad and systemic approach, because of the great complexity of wicked problems, value chains and polycentric multi-actor settings involved. Policy mixes in the sense of instrument mixes have been applied in environmental policy in various contexts (for instance see OECD 2007), inter alia: for a more sustainable management of Icelandic fisheries by setting total allowable catch rates, introducing individual tradable quotas and adding a fisheries resource rent tax (Arnason 2008); to reduce primary aggregate use through an instrument mix consisting of an aggregates levy and a landfill tax for construction and demolition waste, with partial recycling of tax revenues to support research and development for the use of secondary aggregates materials (Söderholm 2011); for reducing plastic waste in the environment in Ireland through introducing a tax on plastic bags accompanied by voluntary initiatives and awareness-raising campaigns (Ecorys et al. 2011); for reducing fertiliser use in Denmark through national action plans comprising fertiliser taxation, monitoring and enforcement mechanisms and farmer extension services (Lindhjem et al. 2009).

However, in several examples the policy mixes seem to have been designed in the sense of adding new policy instruments when necessary without considering potential interactions and long-term consistency (so-called policy-layering, see del Rio and Howlett 2013). In this context, the concept of policy mixing seems promising because it aims to be more than an instrument mix. A policy mix combines several policy instruments aimed at achieving one or several interlinked policy objectives by (a) tackling the most important drivers underlying the need for policy support; (b) trying to maximise positive relations between the instruments.

In political sciences, looking at policy instrument mixes has emerged as a more nuanced model for analysing public policy in the 1990ies. For instance, Gunningham and colleagues (Gunningham and Young 1997; Gunningham et al. 1998) focused on optimal policy intervention by integrating selective regulation with market-based approaches to design sophisticated instrument mixes. Further research showed that both the design and the implementation of policy mixes are very much context dependent – and hence are complicated by information deficiencies, existing actor constellations and strategic considerations, which enter decision-making processes in real-world situations and increase the risk of mismatch between policy instruments and outcomes (Howlett 2004; Minogue 2002).In order to successfully respond to and be adapted to the specific context, the development of policy mixes needs to consider:

- The full range of policy instruments.
- Costs of policies (implementation costs, transaction costs, compliance costs).
- Potentially negative side effects of policy on target groups (e.g. issues of competitiveness for industry or regressive effects on lower-income households).
- Options to combine instruments to mitigate such side effects.

[2] This section is based on and adapted from Ekvall et al. (submitted).

- Political processes during design and implementation. (del Rio and Howlett 2013; Howlett and Rayner 2007

Three DYNAMIX policy mixes were developed through a systematic systems approach elaborated based on the heuristic framework adapted from Givoni et al. (2013). This encompasses the following stages (see Figure 1 below):

1. Defining longer-term objectives and setting of short- to medium-term, more concrete targets for the respective policy areas;
2. Elaborating a theoretical causal model for problem solving in the policy areas (what is the problem situation? What are contributing drivers? What does impede changes?);
3. Selecting, based on heuristics and expert guessing, promising instruments from known potentially relevant policy instruments contributing to problem solving to form an initial policy mix;
4. Undertaking ex-ante assessments (literature based qualitative assessments, participatory scenario building and quantitative computer model simulations) of the initial policy mix as to its potential effectiveness and impacts. This usually entails comprehensive scientific analyses, which then enable substantiated decision-making as to whether or not to include the instrument analysed into the mix;
5. Adding, if the initial mix was found sub-optimal against the set objectives and targets, further instruments to the mix or revising existing instruments and re-running the assessment (repetition of steps (3) and (4)) to finalise the policy mix;
6. Preparing the final policy mix for implementation, enforcement and monitoring.

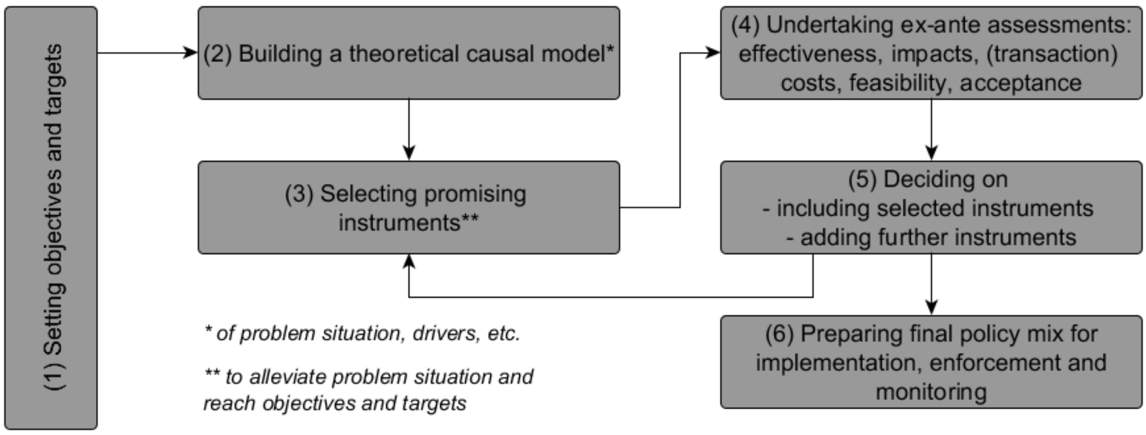

Figure 1 Heuristic framework for policy mix design; adapted from Givoni et al. (2013)

The final stage of the framework was not undertaken as the DYNAMIX project aims to give recommendations to European and national policy makers, but not to prepare a mix for implementation or enforcement.

With the DYNAMIX targets already introduced (see Umpfenbach 2013), the next steps consist of building a theoretical causal model of the problem situation, i.e. identifying key drivers for unsustainable resource use, and selecting promising instruments to tackle those drivers.

2.2 Drivers for unsustainable resource use[3]

Designing policy mixes requires developing a robust understanding of key drivers that affect sustainable resource use in order to best tackle those drivers through policy.

A review of the global and macro-economic flows of resources and their uses can give an indication on which resources are used most inefficiently and where in the life cycle this occurs. The resources that are used the most in the economy are not necessarily those used in a least sustainable way, but the total flow of resources in the economy provide an idea of which types of resource should be used more sustainably. These will be:

- The EU food system is particularly resource intensive in terms of biomass extracted, freshwater withdrawals, land use and application of fertilizers. While there is significant potential to improve resource efficiency related to agriculture and food production, the greatest potential seems to lie in addressing food consumption: diets, overconsumption and food waste (BIO Intelligence Service 2010; 2012; Gustavsson et al. 2011).
- Global energy consumption increased from approximately 4,674 million tonnes of oil equivalent (Mtoe) in 1973 to 8,918 Mtoe in 2011 (IEA, 2013). The installed capacity from renewable energy sources (hydro, solar PV, wind and other sources, incl. geothermal and bioenergy) increased from some 35 GW in 2000 to more than 120 in 2014 (IEA 2015a). Fossil fuels deliver more than 75% of EU's primary energy consumption, while renewables represent about 10% of current energy consumption, but could potentially cover all EU energy demand (Tan et al. 2013). While renewable energy sources could reduce GHG emissions significantly, this involves large investments and might even put a even greater strain on the use of other resources, e.g. land and water to produce bioenergy, critical raw materials to produce photovoltaics and wind turbines.
- Compared to other resources, metals are generally the most valued within the economy. Despite being inherently recyclable, they are often sent to landfills at their end-of-life (UNEP 2011). Besides reducing the demand for metal through better design and longer product lifetimes, closing material loops promises great potential for increasing resource efficiency of metals (Allwood et al. 2011).
- Minerals also have the potential to be more efficiently reused and recycled, however the greatest potential for improving the resource efficiency of construction minerals is through better design and planning of buildings and infrastructure (Allwood and Cullen 2012). It also holds the potential for more efficient use of land, energy and water related to buildings and urban areas. Other minerals, phosphorus in particular, are used very inefficiently with losses occurring throughout the life cycle (Cordell et al. 2011).
- The main inefficiencies related to land use is land conversion from natural land to agricultural or built-up land (particularly, urban sprawl and transport infrastructures) (JRC 2012; Prokop et al. 2011).

A variety of interlinked factors was found underlying such unsustainable resource use. In most of the existing literature on resource efficiency, population growth and rising income (affluence) are identified as two of the main root causes of existing unsustainable patterns of

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[3] This section is based on and adapted from Hirschnitz-Garbers et al. (2015) and Tan et al. (2013).

resource use. However, rising income and population growth are mainly indirect drivers – there are other factors with more direct influence on resource inefficiency. Our analysis points to drivers that constitute part of the complex interplay of factors: in particular consumption and production patterns that translate the increasing affluence of ever more people (emerging middle-class consumers) into lifestyles and habits associated with high resource use. This was observed in relation to areas such as:

- dietary choices (high meat and dairy consumption),
- choice of transport modes and distance travelled (more use of individual transport modes, increasing air travel), and
- housing preferences (larger living spaces per person, increasing number of appliances in use).

All the above mentioned drivers appear to be directly affected – or at least indirectly influenced – by either resource efficiency fostering or impeding legal frameworks, administrative settings and political actions. Further drivers identified were environmental concerns (mainly in relation to water pollution), resource prices, and supply insecurity. While it can be discussed whether environmental concerns as such are sufficiently powerful drivers for more efficient resource use, resource prices and supply insecurity were considered powerful drivers that case studies demonstrated to have already led to improvements in resource efficiency. Both have direct economic impacts on business, trade and competitiveness.

The analyses yield a multi-dimensional complex network of drivers (a "web of drivers") whose cumulative effects cause or contribute significantly to unsustainable use of resources. Figure 2 shows an exemplary web of drivers for selected case studies from literature analysis.

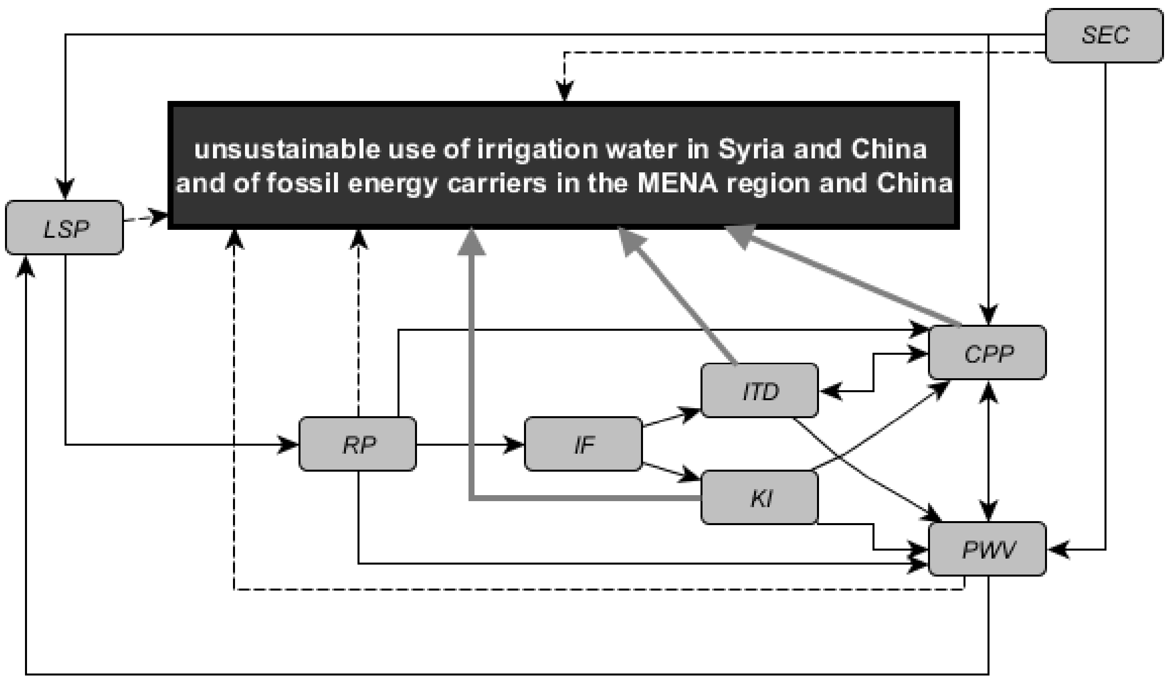


Figure 2 Exemplary web of drivers for unsustainable resource use; Hirschnitz-Garbers et al. (2015): 13

CPP = Consumption & Production Patterns; IF = Investments/financial & human resources; ITD = Infrastructure & Technology Design/use; KI = Knowledge & Information; LSP: Legal-

administrative settings and political action; PWV = Paradigms, world views, perceptions, aspirations; RP = Resource prices; SEC = Socio-economic conditions

Figure 2 shows direct effects (grey solid arrows) on unsustainable resource use for some drivers and indirect effects (black dashed arrows) for others. The causal network of drivers will be too simplistic in some aspects, but the figure captures that for the cases in question, there is no clear-cut, single causation of unsustainable use. Nonetheless, public subsidies (*LSP*) for groundwater use in Syria (Yigezu et al., 2013) and China (Fan et al., 2012) as well as for fossil fuel use in the MENA region (Fattouh and El-Katiri, 2013) may be a root cause as they cause low prices (*RP*) for energy use and groundwater abstraction. These in turn discourage investments (*IF*) in more efficient irrigation infrastructure as well as in more efficient energy provisioning systems (including renewable energies). Additionally, lacking investments also limit the provision of knowledge and information (*KI*) on efficient use of resources, hence maintaining existing levels. *KI* and *ITD* exert direct effects on the unsustainable use of irrigation water and fossil fuels, for instance because farmers in Syria and China do not have knowledge, nor the technologies to apply the right amount of water at the right times using efficient technologies. Furthermore, households in the MENA region do not have much other choice than using electricity generated from fossil fuels as renewable energy accounts for only 5% of energy provision in the region (Fattouh and El-Katiri, 2013). Therefore, more sustainable energy consumption behaviour and irrigation management practices (*CPP*) in both cases are limited by a lack of knowledge on and availability of alternatives. This also influences prevailing paradigms and aspirations (*PWV*) as lacking alternatives and low resource prices convey a notion of abundance of fossil fuels and of prevailing resource use behaviour to be appropriate.

The economic structure of the MENA region (i.e. socio-economic relevance of energy-intense industries, such as petrochemicals) and rising affluence in China (*SEC*) further affect unsustainable resource use. In the former case, representatives of energy-intense sunrise industries use their industries' socio-economic relevance to convince governments that low resource prices (*LSP*) need to be maintained in order to keep the country's competitive advantage (*Ibid.*). This locks the driver network presented in Figure 2 into a vicious cycle. In the latter case, rising affluence of many Chinese households enables the pursuit of more resource intensive lifestyles and correspondingly increase the demand for related resources and services (*CPP*), such as energy and concrete for mobility and housing (Güneralp and Seto, 2012). Such demand materialises in aspirations for more floor space per person and increased use of heating/cooling (*PWV*), but also triggers expansion of mobility and housing infrastructure (*ITD*). Hence, the direct effects of rising affluence unfold through *CPP* and *ITD*.

The findings from the analyses of drivers contribute to an improved and more comprehensive picture of relevant drivers affecting unsustainable resource use. This picture then serves as a guide for looking at specific policy areas for examples of past successful or failing policies in order to inform the design of the DYNAMIX policy mixes.

2.3 Lessons learnt from past policy[4]

Based on an ex-post case study analysis of 16 environmental policy mixes from Europe and beyond (see Mazza et al. 2013) the impact of policy mixes on decoupling was found to be very time dependent because in most cases the policies need to be implemented over many years to achieve their effects. This is due to the time needed for substitutions of resources, processes and products, for innovation, demand changes and the evolution of social norms,

[4] This section is based on and adapted from Fedrigo-Fazio et al. (2014).

infrastructure investments and to overcome technological lock-in. Table 1 presents examples of policy mixes and their contributions to decoupling to date.

Table 1: DYNAMIX case study policy mixes

Case studies
Sustainable levels of fish catch in Iceland: A mix of setting total allowable catches, and introducing individual tradable quotas and a resource tax has allowed fish stocks to recover and be at more sustainable levels. Herring recovered from a 1960s collapse and Icelandic cod increased from 500,000 t in 1992 to 1.2 million t in 2012.
Reducing fertiliser use in Denmark: Excessive fertiliser use causes serious negative environmental impacts especially in water ecosystems. A range of instruments, with regulatory ones at the core were implemented. Nitrogen fertiliser use has reduced by almost 50 % from 394,000 t N in 1990 to 203,900 t N in 2011. **More efficient use of aggregates in the UK:** Due to the variety of negative environmental impacts of the use of aggregates, an aggregates levy and a sustainability fund were introduced, complemented by an existing landfill tax. This policy mix managed to achieve a decrease in primary use of aggregates while achieving an increase of the construction output. **Reducing plastic bag use in Ireland and the UK:** Through a mix of taxes, voluntary initiatives and awareness-raising campaigns Ireland reduced plastic bags use by 90 % within five months after introduction of the policy mix. **A sound material cycle society in Japan:** Expected increasing dependency on raw materials and critical metals imports motivated Japan to introduce a policy creating a 'sound material cycle society', using national targets, R&D and subsidies but also awareness-raising campaigns to promote mainly recycling.
Reducing fossil fuel use in Sweden: Through long-standing taxation instruments, a tradable certificate system and various political strategies and regulation, Sweden has reduced CO_2 emissions (0.5 % per year) but the picture is less clear on total energy consumption. Different instruments were used to address various sectors. **A fossil fuel-free energy system by 2050 in Denmark:** Denmark's extensive use of taxation of energy and CO_2 is built upon by more recent political strategies aiming to end fossil fuel dependence by 2050. CO_2 emissions have decreased, while energy consumption shows a slight decreasing trend. Although difficult to quantify robustly, a transition from relative to absolute decoupling appears to be occurring. Support across political parties features heavily in Danish policy, with very positive effect. **Reducing municipal waste at the local level in Slovakia:** Palárikovo municipality adopted a "Zero Waste" strategy, based initially on an awareness-raising campaign and recycling infrastructure introduction. The pay-as-you-throw scheme introduced had a strong reinforcing effect. Landfilled waste decreased by 64 % from 1999-2011. **Conserving rural land in England:** Use of planning acts, identification of land that should not go to development and areas that are available to development, combined with incentives have helped reduce net land take to around 5,000 hectares per year. **Reducing land sealing in Germany:** A national 2020 goal of taking no more than 30 hectares per day was set to limit additional land take. Modest progress has been made, particularly given lack of unity in tools used and contradictory instruments.
Sustainable use of forests and wood in Finland: Use of regulation, voluntary schemes and forest certification has helped reduce use of domestic forestry products and increase forest stock/standing

Case studies
forest biomass. However, increased imports of wood products are offsetting domestic progress. Overall decoupling had not been achieved. **Reducing transport CO_2 emissions in Spain:** Although there was a decrease in CO_2 emissions in the final year of the policy mix (2007), this is more likely due to the global economic and financial crisis and due to how GDP time series is constructed. The policy mix focuses on information instruments. **Increasing industrial energy efficiency in Portugal:** The policy mix used a mixture of regulatory and economic instruments. However, industry energy consumption is still coupled with economic growth, despite GHG emissions having decreased.
Reducing phthalate and PVC use in Denmark: Through instruments such as bans and taxes, Denmark succeeded in reducing consumption of phthalates and PVC by around 50 %. These two substances have significant negative human health impacts. **Preventing food waste in the UK:** In efforts to decrease methane emissions, this policy mix used the existing landfill tax and information campaigns targeted at consumers. 1.1 mt of food waste were prevented.

Source: adapted from Fedrigo-Fazio et al. (2014)

Several key factors for success emerged from the case study analysis:

Policy mixes focused on a specific resource or sector are more likely to achieve absolute decoupling. Examples include: Iceland's fisheries management; the UK's aggregates consumption; Denmark's fertiliser use; and Ireland and the UK's plastic bags use.

There is no obvious trend between the absolute number of instruments in a policy mix and its effectiveness. Addressing resources used in various sectors and potentially for different uses in an economy needs policy mixes using a number of different types of instruments. One policy instrument per aspect of policy target and per market failure has been found most beneficial in designing effective policy mixes.

Information instruments are key in development of natural resources policies. However, used in isolation, they will usually fail to deliver the scale of change required for decoupling. Company transparency and accountability can be improved through information-based instruments such as labels. Nonetheless, heavy dependence on information-based tools needs to be handled with care. In product policy, a long held perception persists that providing the public with more information through labels can help them make more informed (and sustainable) purchasing decisions. Amongst other factors, habits, social norms, choice, social status also play significant roles in decision-making. General evidence has shown that consumer information could only bring about significant behavioural change if accompanied by other measures as part of a strategic approach. However, such information-based activities can help raise awareness of key issues and act as a *precursor* to more ambitious activities. For resources about which relatively less is known, the role of information plays a vital role in setting the scene for future activities, for example in the area of critical metals.

A clear understanding of limits and thresholds encourages more effective moves towards absolute decoupling. Examples include:

- Fisheries in Iceland, where the setting of total allowable catches on how much fish can be caught were a key element in the policy mix, which also underlines the importance of defining the limits with reference to the appropriate geographic scope.
- Restrictions on fertiliser use in Denmark, where clear targets were set and the estimated contribution of the various initiatives was also provided; regular policy review also ensured that revisions to strategies were more effective.

Policy mixes addressing all phases of the policy cycle are more likely to be effective in the long term – especially having targets and built-in monitoring, review and response mechanisms. Examples include:

- Denmark's fertiliser use: a good illustration of how continued monitoring can serve as a trigger for progressive tightening of the policy mix in light of trends showing that additional policies and measures were needed if set targets were to be achieved.
- Given the scarcity of water resources in Australia, a system of water accounts has been recording annual water consumption per sector of final use (e.g. agricultural, households) since 2000-2001. This has enabled monitoring of the water trading system, which has reduced and shifted water use across sectors.

Effective policy mixes struck the right balance between effectiveness and acceptance. Examples include:

- The UK aggregates levy: the recycling of parts of the levy revenues generated and targeting them to the Aggregates Levy Sustainability Fund is thought to have made the introduction of the levy more acceptable to the extraction industry affected and helped the sector further reduce its environmental impacts.
- Carbon and energy taxation experience has shown that some form of exemptions and/or tax reductions are often a necessary component of environmental tax reform (ETR) and are relied on as a politically expedient measure. However such practices often impair the effectiveness of ETR as the cheapest emission reduction potential is not exploited.

Internationally traded resources require policy mixes addressing global impacts of resource use, particularly imports. Shifting of burdens from the EU to the rest of the world is already a recognised reality, falsely presenting some EU Member States as having increased resource efficiency. The Finnish wood example illustrates how domestic improvements can come at the expense of international imports with sometimes dramatically more negative impacts.

Policy mixes need to be designed in relation to the level and type of 'lock-in' to achieve transformation. The ease or not of transformation is dependent upon the level of (inter)dependency or 'lock-in' of economic and social systems in relation to a resource or product in question. Systems thinking is required, to understand the range of inter-linkages, to identify where there are issues of particular lock-in or market failures that need addressing. This will require multi-level governance across stakeholders in society and the economy. Dynamic mixes of policy instruments with specific designs to address different issues and objectives, and reflecting a diversity of country contexts are needed to decouple the economy.

Observed shortcomings in the policy mixes and challenges for future policy design

Incomplete policy mixes can fail to comprehensively target all sectors or products responsible for the overuse of a specific resource, or can focus too narrowly on impacts of resource use accruing domestically thereby failing to address resource extraction and use impacts across the global value chain. Examples include:

- The sustainable forestry policy mix in Finland, where domestic wood production appeared to have stayed within limits while imports of potentially unsustainably (and illegally) harvested wood increased importantly.

Rebound effects are only insufficiently taken into account in most of the policy mixes. Rebound effects were not addressed in the policy mixes analysed, despite being relevant to a wide range of them.

Targets and objectives that are not fit for purpose undermine progress towards decoupling. Of those policy mixes having achieved absolute decoupling two thirds were developed with clearly defined quantitative targets to be met within a set period of time (Denmark's fertiliser use and phthalates/PVC, Japan's raw materials, Ireland and UK's plastic bags). Of those not yet achieving decoupling, half of the policy mixes did not have measurable targets (e.g. wood in Finland and food waste in the UK).

EU resource use policy is already building upon existing policies in a wide range of areas such as agriculture, air quality, biodiversity, chemicals, climate, energy, fish, waste and wood. In most cases, effective policy demands setting clear targets, using regulatory instruments supported by economic incentives and voluntary measures, and a built-in consistent monitoring system for the policy to be successful.

The lessons learnt from driver analyses and ex-post analyses were then used as much as possible to design promising policy mixes for ex-ante assessments of potential impacts.

2.4 Policy mix designs[5]

Based on previous findings three policy mixes were designed to:

1. reduce land use, freshwater use and nutrient surplus through improvements in food production, changes in diet, and reductions in food waste ('land policy mix');
2. reduce the use of virgin metals in the EU through increased recycling and material efficiency. At the same time, it aims to avoid merely shifting burdens to the use of other resources or regions in the world, or to increase environmental impacts. For this reason, the policy mix also includes competing materials ('metals and materials policy mix'); and
3. reduce overall resource consumption and environmental impacts through creating supportive framework conditions for producers and consumers to make more sustainable choices ('overarching policy mix').

Each policy mix was developed within a separate author team, using a common methodological framework. The policy mixes were developed based on previous findings in the project:

[5] This section is based on and adapted from Ekvall et al. (2015).

we had investigated the current use of resources to identify and identified reasons for both efficient and inefficient resource use in the economy.

2.4.1 Land policy mix[6]

The environmental impact related to the EU's consumption and production of agricultural products continues to grow, both within and beyond the EU. Through increasing net imports of agricultural products, the EU is contributing to the rising global demand for agricultural land. Next to a growing world population, the main drivers for rising demand for agricultural land are changing diets –especially increasing consumption of meat (Herrero et al. 2009; 2013) – as well as food waste and the increasing consumption of first generation biofuels (Underwood et al. 2013; UNEP 2014). Rising global demand for agricultural land has not only added to pressures on land use in other countries, but has also shifted the environmental (and social) burden of EU consumption (SERI 2011). Expressed in numbers, the EU-27 used about 0.31 hectares (ha) per capita of cropland at the global level in 2007– one third more than the cropland that is globally available in per capita terms (Bringezu et al. 2012).

One relevant factor in this development is the shift in diets towards more animal products. The European per-capita consumption of animal food products increased by 50% between 1961 and 2007. Today, the consumption of meat and dairy products in Europe corresponds to two and three times the world average respectively (Westhoek et al. 2011). Regarding protein supply, meat production has a much higher land consumption compared to protein from plant sources. In fact, one third of the worldwide available cropland is used for the production of feed (Wirsenius et al. 2010). Chickens require about 2-3 kilogrammes (kg) of feed to produce 1 kg of meat, whereas cattle can require up to 16 kg of feed to produce 1 kg of beef (Gold 2004). Excessive meat consumption is also associated with health risks. For European citizens, the average per-capita intake of saturated fatty acids associated with animal products is about 40% higher than levels recommended by the World Health Organisation (WHO). Such dietary conditions pose an increased risk of cardiovascular diseases.

In contrast to the global development, the area of agriculturally used land in the EU is declining. Two major trends are driving this process: the intensification of agriculture – particularly in areas with productive soils - and the abandonment of farmland (EEA 2010). Both these trends are detrimental for biodiversity.

Intensification and specialisation of agriculture, such as the frequent use of chemical fertilisers, plant protection products and heavy machinery often reduce ecosystem quality and create conditions which are hostile to wildlife and natural vegetation (Poláková et al. 2011). Agricultural practices with negative impacts on biodiversity have become widespread over much of the EU over the last 30-50 years, especially in the north-west. Consequently this has resulted in widespread and significant population declines of various species.

At the same time, extensive traditional farming systems in marginal agricultural areas are being abandoned, as they are no longer economically viable. As extensive traditional farming systems present an important habitat for a range of species and are often characterised by very high biodiversity values, their abandonment and subsequent degradation forms a central threat to biodiversity in the EU (Keenleyside and Tucker 2010).

[6] This section is based on and adapted from Hinzmann (2016).

Pressures on soils caused by agricultural practices include soil compaction through the use of heavy machinery, erosion by water (it is estimated that 1.3 million km² are affected in the EU27) and a decline in organic matter (45% of soils in Europe have low or very low organic matter) (Jones et al. 2012). Although it is in the farmer's interest to manage soil resources in an environmentally sustainable way, this interest appears to be often overridden by the short-term economic incentive to maximise productivity.

On the whole, current agricultural production practices are detrimental for biodiversity, soils and water resources. The most important policy for EU agriculture is the Common Agricultural Policy (CAP), which provides direct subsidies to farmers and also subsidises a range of agricultural activities that involve farmers. The CAP includes different instruments that promote eco-friendly farming, such as cross compliance or the 'greening component', under which farms have to comply with basic levels of environmental management to secure subsidies. However, numerous exemptions exist for the greening component, and its potential impact on farming practices appears to be limited in its current form.

The land policy mix aims at progressing towards a more sustainable use of land both at the European and at the global level. Therefore it targets both the consumption and the production side of the agricultural sector. The policy mix consists of eight instruments. Five instruments[7] on the production side aim to enhance biodiversity, soil quality and water quality. In addition, they aim to improve human health and contribute to climate change mitigation.

- Revision of the Common Agricultural Policy (CAP)
- Measures limiting nitrogen emissions
- Regulation for Land Use, Land Use Change and Forestry (LULUCF)
- Improved pesticide management
- Promotion of Payment for Ecosystem Services (PES) programmes

The three instruments on the consumption side aim to change dietary habits – particularly to reduce meat consumption – and to reduce food waste.

- Value added tax (VAT) on meat products
- Targeted information campaigns on changing diets and on food waste
- Development of food redistribution programmes

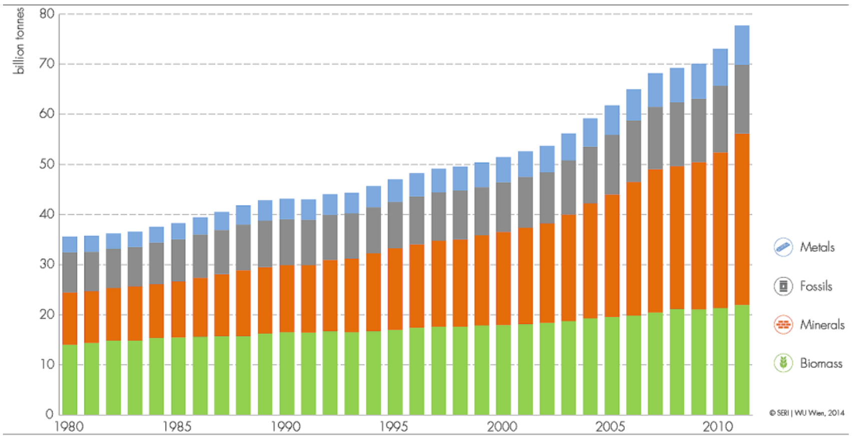
2.4.2 Metals and materials policy mix[8]

The welfare of modern societies relies heavily on the use of metals in infrastructure and products. Each year, the EU-27 uses 600-800 megatonnes (Mt) of metals (raw material consumption; RMC) with a slightly increasing trend (+2.3%/year). In contrast to many other resources, metals are often recyclable, albeit big differences exist between metals. Mass metals like iron are abundant and used in large quantities, other metals are rare – or at least not available in high concentrations. For a majority of extracted metals, ore grades in mines are going down, increasing the technical effort needed and thus the costs of metals extractions. Mining increasingly low ore grades leads to high energy use and greenhouse gas emissions, as well as to higher environmental pressures. Today, the metals industry demands over 6% of the

[7] Selected instrument fact sheets for the land policy mix can be found in the Annex to this report.
[8] This section is based on and adapted from Langsdorf (2016).

global energy (IEA 2015b). In addition, some metals, such as cobalt, are extracted mainly in politically unstable regions, leading to security and social problems.

Figure 3: Global resource extraction by material category 1980-2011; SERI and WU Wien 2014



Metals are required for all sectors of the economy, and many drivers and barriers influence their use. Naturally, the overlying driver of virgin metals use is our economic system, in which business models focus on the sale of products (rather than services) and which relies on constant economic growth. From this core arise a great number of drivers and barriers, which are often intertwined and reinforcing, such as:

- Consumer culture; including the function of products as status symbols;
- High income levels and low material costs, leading to user behaviour which favours throwing products away before the end of life and new purchase over repairing and maintaining (throw-away society);
- This is reinforced by the economic system providing products that cannot be repaired (dismantling is impossible and/or spare parts are not available); and not providing repair services, making repair often not only the more expensive but also the more time-consuming choice;
- Preference for private ownership, even if products (or buildings) may be infrequently used.
- High quality and safety standards also drive the use of virgin metals in the EU. Manufacturers must ensure certain standards for products and thus opt for extra materials to reinforce products and ensure robustness;
- Knowledge gaps and underinvestment in research and development.

Technically, it would be feasible to reduce global metal production considerably (by almost one-third according to Allwood and Cullen 2012) through design. Furthermore, a large part of the demand in the EU could be satisfied through recycling and circular economy strategies. In 2003, the EU had a metal stock of 3200 Mt in use, and an estimated unused stock in landfills of about 2250 Mt. Tapping these potentials and going beyond them requires bold policy interventions. The respective DYNAMIX target (see Umpfenbach 2013) is bold: reducing the consumption of virgin metals by 80% in the EU in 2050 – without major increases in the use of other resources or environmental impacts.

To this aim a policy mix was developed that encompasses five main instruments[9]:

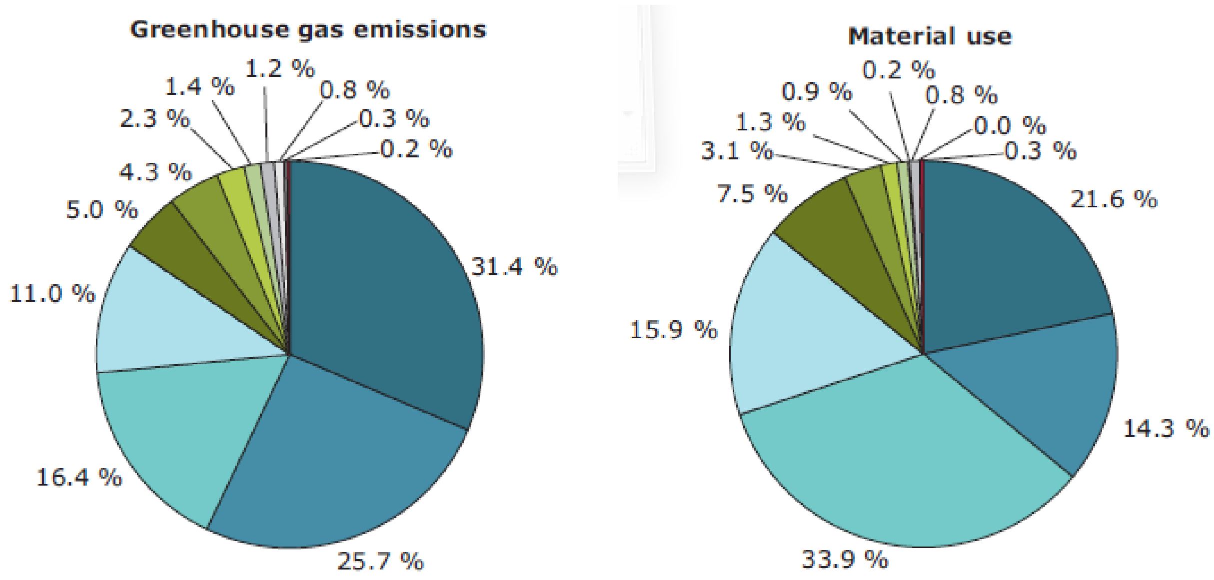
- a green fiscal reform (GFR) including the "internalisation of external environmental costs" and
- a gradually increasing "materials tax";
- the promotion of sharing systems;
- introducing stricter product standards that shall increase the repairability and longevity of products; and
- increasing research and development for material efficiency and improved recycling.

These main instruments were embedded in five supporting instruments: an EU strategy for dematerialisation; information campaigns; the establishment of fora for communication; removal of environmentally harmful subsidies and the establishment of advanced recycling centres.

2.4.3 Overarching policy mix[10]

The overall environmental impact related to the consumption of goods and services by households and businesses in the EU continues to grow, both within and beyond the EU. Three consumption categories were found to account for more than two thirds of consumption-related greenhouse gas (GHG) emissions and material use: food and drink, housing and utilities, and transport/mobility (see Figure 4 below) (EEA 2013; Tukker et al. 2006).[11]

Figure 4: Greenhouse gas emissions and material use caused by private (household) consumption by consumption category, EU-27, 2007; Source: EEA (2012): 15, adapted



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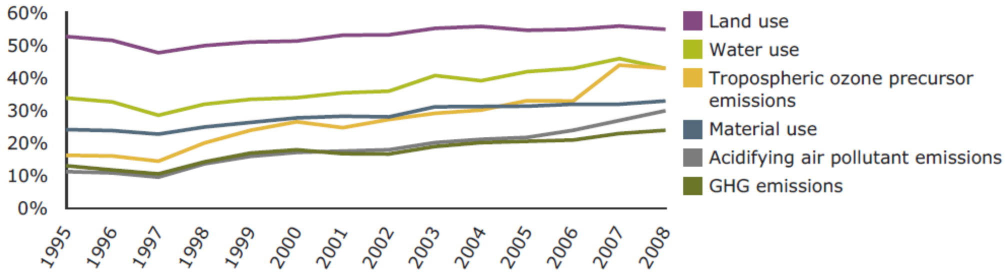
[9] Selected instrument fact sheets for the metals and materials policy mix can be found in the Annex to this report.
[10] This section is based on and adapted from Hirschnitz-Garbers (2016).
[11] Based on an analysis of nine EU Member States (Austria, Czech Republic, Denmark, France, Germany, Italy, the Netherlands, Portugal and Sweden), representing 268 million or 53.5 % of the EU's total 501 million people (EEA (2013).

Housing, water, electricity, gas and other fuels
Transport
Food and non-alcoholic beverages
Furnishings, household equipment and routine maintenance
Restaurants and hotels
Recreation and culture
Miscellaneous goods and services
Clothing and footwear
Health
Communication
Education
Tobacco and narcotics

Since an increasing share of the final and intermediate goods consumed in Europe are produced outside of Europe, we shift a growing proportion of impacts of our consumption (linked to the extraction of materials, processing and manufacturing and transport of final and intermediate goods) to other parts of the world. From 1995 to 2008, the share of several environmental impacts related to EU consumption grew – for instance, GHG emitted outside the EU increased from 13% to 24% (EEA 2015) (see Figure 5 below).

Figure 5: Percentage of the EU footprint exerted outside EU borders; Source: EEA (2015): 37



A web of interrelated drivers appears to lie at the root of observed trends towards increasing consumption over the last decades. Drivers include population growth, rising affluence, decreasing production prices, increasing pace of product innovation, increasing availability of consumption choices through the expansion of trade, fossil-fuel dominated infrastructures and consumption patterns shaped by social norms, advertising and consumerist values.

This web of drivers raises the key question of if and how policy could foster sustainable consumption behaviour (see Hirschnitz-Garbers et al. 2015). Information-based instruments (such as product eco-labelling) are popular and used wide-spread to promote behavioural change. While important to improve consumer information and awareness, evaluations of such policies have shown that information-based instruments used in isolation are not effective.[12] This calls for combining different additional policy instruments as part of a policy mix (see e.g. Givoni et al. 2013).

Research from the multi-disciplinary fields of behavioural economics and sociology of consumption has produced evidence that framing, anchoring, mental shortcuts, information overload and emotions play a crucial role in consumer decision-making (Kahnemann 2011). Furthermore, learning from research using practice theory everyday practices, such as consumption choices, are shaped by the interplay of materials (for example infrastructure and technology), competences of consumers (mainly skills and knowledge) and meaning to the consumers (referring to values, attitudes and emotions) (Shove et al. 2012). Hence, instead of focusing on the individual and its general attitude towards the environment, consumer policies need to consider and integrated the impact of social groups and social practices (for example bike riding or car sharing) (see e.g. Umpfenbach 2014).

[12] Fedrigo-Fazio, Doreen, Leonardo Mazza, Patrick ten Brink, and Emma Watkins. 2014. Comparative analysis of policy mixes addressing natural resources. Deliverable 3.2 of DYNAMIX. London/Brussels: Institute for European Environmental Policy.

Against this background of a complex web of interlinked drivers that cause unsustainable consumption, the overarching policy mix aims at combining instruments that could help creating supportive framework conditions for producers and consumers to make more sustainable choices.

The overarching policy mix comprises eight policy instruments[13]:

Longer-term objectives	Instrument
Encouraging a shift from working time to more leisure time for sustainable activities	(1) Labour market reform fostering a shift from consumption to leisure
Enable more responsible choices vis-à-vis overconsumption and waste generation	(2) Step-by-step restriction of advertisement and marketing
Products are more easily repairable and have longer durability and operational lives	(3) Boosting Extended producer responsibility (EPR) schemes
Smart pricing – full cost pricing for resource provision, internalisation of externalities to the extent feasible	(4) Tax on material use, incineration and landfilling (Circular Economy Tax Trio) Price incentives for resource-efficient products through (5) feebates and (6) VAT reductions
System innovation replacing inefficient and resource intensive systems is fostered	(7) Skill enhancement programme (8) Support for local currencies

3 Potential impacts of the policy mixes

In the context of the ex-ante assessments, the three policy mixes (and the policy instruments contained therein) were analysed as to their potential environmental impacts, as much as possible in relation to the key environmental targets (Umpfenbach 2013) (section 4.1).

In Section 4.2, we highlight potential side-effects of the policy mixes (economic and social impacts as well as issues of legal feasibility and public acceptability) that may reduce their potential environmental effectiveness of achieving the key environmental targets.

3.1 Environmental impacts – support for decoupling

3.1.1 Land policy mix[14]

Overall, the policy mix can be considered having positive **environmental effects,** as in combination the eight policy instruments will:

- Reduce the overall fertiliser input and promote an efficient application of fertilisers;
- Decrease pesticide use;
- Promote the protection and creation of habitats;
- Reduce food waste; and

[13] Selected instrument fact sheets for the overarching policy mix can be found in the Annex to this report.

[14] This section is based on and adapted from Hinzmann (2016).

- Promote a change in diets away from meat and dairy products.

Benchmarked against achieving the DYNAMIX environmental key targets, with great likelihood the policy mix will contribute to four of the five targets.

Target: Limiting emissions to 2 tonnes CO_2-equivalent per capita per year by 2050.

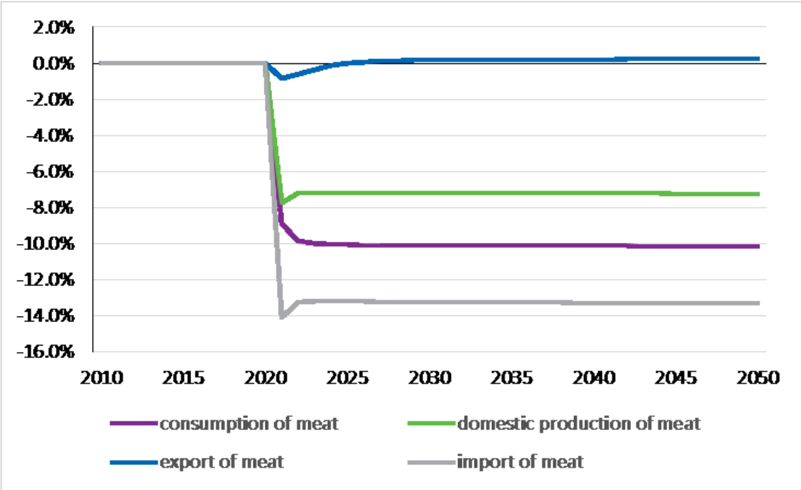
According to findings for several instruments of the land policy mix, the mix very likely significantly contributes towards achieving the DYNAMIX target on climate, assuming full effectiveness of its component measures.

Considerable cuts in GHG emissions can be achieved through the reduction of meat and milk consumption. The reason for this is that various GHG emissions are related to livestock production. These include methane (CH_4) emissions caused by the digestive process of ruminants, nitrous oxide (N_2O) stemming from manure, as well as CO_2 emissions related to food processing, transport and the production of mineral fertilisers needed to grow feed crops. In addition, further indirect CO_2 emissions are caused by the conversion of forests into cropland for feed production. However, there are risks that the impact of reduced consumption in the EU would, in part, be accompanied by a lowering of global prices, leading to increased consumption elsewhere, reducing its overall effectiveness in tackling environmental issues.

For the VAT on meat products, different economic models were used (ICES, MEMO II and MEWA) to simulate an average one-off increase of the consumption tax on meat products by 13% in 2020 and its impact on the EU as a whole (Bosello et al. 2016). The simulations showed similar results: The VAT on meat is moderately successful in reducing meat consumption, while domestic meat consumption is decreased to a lesser extent. The latter can be explained by slight increases in meat exports due to a decrease in meat prices in the world market following the EU demand contraction. Figure 6 shows the results of the MEWA model, i.e. a 10% fall in the consumption of meat and an approximate 7% fall in the domestic meat production, both for the short- and long-term (IVM et al. 2008)[15]. In fact, the MEWA simulations produced overall the most optimistic results in comparison with the other models. It assumes that the EU share in demand on the international meat markets is too small to significantly influence prices on the global level. Thus, meat exports do not rise substantially. Next, it assumes that European meat producers are forced cut meat prices, as they will face a noticeable drop in domestic demand and are confronted with excessive production capacities. The lower prices will result in the substitution of foreign meat by domestic products.

[15] The results of the modelling exercise are in line with IVM et al. (2008). The impact is at higher range of the estimates due to the accompanying information campaign, leading to further dietary changes.

Figure 6. VAT on meat products: Change in sectoral variables in comparison to the baseline



Source: MEWA model simulations

Next, it can be expected that a targeted information campaign can result in considerable emission savings. Albeit information campaigns are in general expected to only have small effects on people's behaviour (Umpfenbach 2014), even such small effects can have a significant impact due to the large direct and indirect GHG emissions associated with both meat and dairy consumption and food waste.

The food redistribution programme might decrease GHG emissions in two ways. Firstly, through reducing food production, and secondly through preventing food waste from going to landfill (Nesbit et al. 2015). In fact, each tonne of food waste prevented results in 4.2 tonnes of CO_2-equivalent emissions avoided compared to landfilling (Defra and DECC 2011).

Further emission reductions can be expected from the production-side instruments. Bigano et al. (2015) estimate that a 10% reduction of GHG from agriculture can be achieved through the revision of the CAP, more specifically through the decrease in fertiliser use and more energy-efficient farming (Bigano et al. 2015). Other instruments will also contribute to more efficient fertiliser use (e.g. measures limiting nitrogen emissions) and thus strengthen this effect. The LULUCF regulation should assist achieving the DYNAMIX target through carbon sequestration (e.g. protection of grassland, afforestation, restoration of degraded soils).

In sum, the expected emission reductions described above constitute an important contribution towards the DYNAMIX target of reducing the GHG emissions to 2 tonnes of CO_2-equivalents per year. However, the DYNAMIX target requires that the GHG emissions be reduced by 80% compared to current emissions (and this target in turn appears insufficient to meet the objectives now set out by the Paris Agreement). Thus, either further reductions would need to be achieved from the agriculture sector, or other sectors would need to reduce their emissions by more than 80%.

It must be noted that there is a risk that the policy instruments cause decreases in productivity, e.g. due to restricted fertiliser use. This could mean that – in case no reduction in consumption takes place – emission cuts are compensated by increased production and associated GHG emissions outside the EU.

Target: Reducing the consumption of arable land in order to reach zero net demand of non-EU arable land

The land policy mix has potential to contribute to achieving the target. Particularly, the consumption side instruments are expected to have positive effects on land use.

For instance, food redistribution programmes could considerably reduce land use, as long as the avoided food waste leads to a reduction in the production of food. For the information campaign, a positive, albeit small impact on land use is expected due to the reduction of land needed for livestock farming (as pastureland, and in terms of the land needed to grow feed crops) as well as a reduction of land associated with food waste. A higher potential impact was assessed by a modelling exercise. Assuming that the instrument was very effective for changing diets, results indicate that the information campaign has the potential to reduce land use by more than 30% (Ekvall et al. 2016). This is depicted in Figure 7 below. In scenario 1, the proportion of animal-based protein was reduced to 35% and 25% for 2030 and 2050 respectively, as outlined in the policy targets. It can be seen in the figure above that in scenario 0 an increase in land occupation will occur, which can be explained by assumed population increases. In contrast, a reduction in the consumption of animal products (scenario 1) will minimise the pressure on land resources. This can be explained by the fact that plant protein production has a lower land footprint compared to animal-based protein. Figure 7 shows the reduction in land occupation in absolute numbers. However, this result is based on a very optimistic assumption about behavioural response of populations targeted by such a measure.

Figure 7: Simulated effect on land use without policy (scenario 0) and with information campaign (scenario 1). Land occupation normalised to the base year of 2010 (Million ha per year).

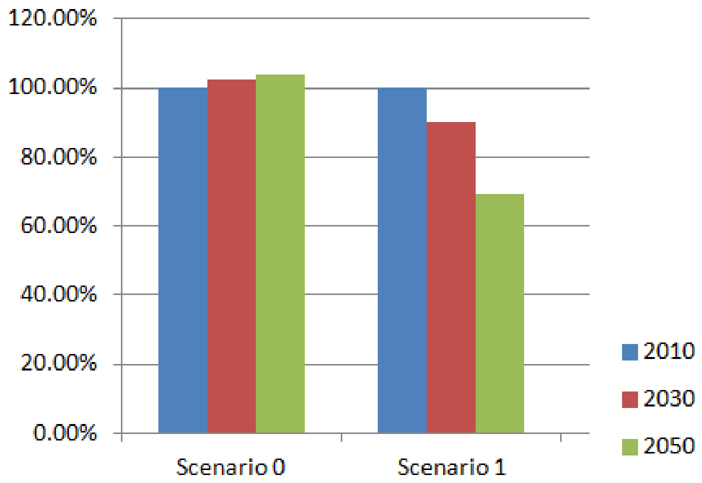


Table 2: Land occupation for Scenarios 0 and 1 (Million ha per year)

Scenario	2010	2030	2050
0) Without policy (continuation of current consumption patterns)	310	320	325
1) Information campaign (optimistic assumption on effectiveness)	310	280	220

In contrast, for the production side instruments, a potential for minor countervailing negative effects has been identified. There is a risk that crop yields decrease – due to e.g. reduced fertiliser use or less effective pest control – could lead to an increased demand for land in the EU and beyond. Small positive impacts can be achieved by creating additional disincentives to the conversion of land to other uses (through the LULUCF regulation) and by improved soil quality, as well as reduced levels of acidification due to the revision of the Nitrates Directive (Nesbit et al. 2015).

It has been estimated that a 30% reduction in land use is sufficient to keep the net demand of non-EU agricultural land below zero (Ekvall et al. 2016). This illustrates the potential for reducing pressure on land from this policy. It has to be noted, though, that the modelled changes in diets depict a radical reduction in the excess intake of protein. Moreover, a critical question in regard to achieving the land use target is how the land becoming available will then be used.

Target: Enhancing biodiversity though the reduction of nitrogen and phosphorus surpluses in the EU to levels that can be achieved by the best available techniques

Although no exact level of contribution to this target can be given, the policy mix very likely contributes to this target. One important factor is the reduction of pesticide use.

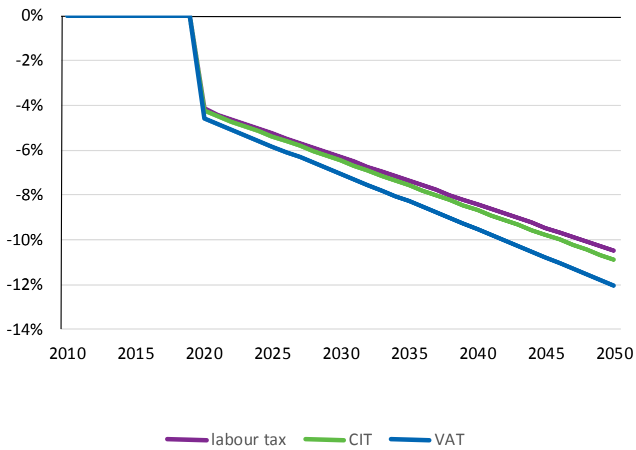
The decrease in pesticide application is expected to mitigate the negative impact on:

- Wild plant diversity, carabids, bees and bird species in Europe (Geiger et al. 2010),
- Freshwater ecosystems. (Beketov et al. 2013; Bundschuh et al. 2014)

In order to have this beneficial effect, it is essential that the reduction in pesticide use goes beyond the mere compliance with current environmental standards. In addition, the reduction of pesticide applications is expected to have a beneficial effect on soil functionality through the reduction of pesticide residues in soil (but only if reduction of pesticide does not lead to increased tillage).

According to the MEWA model simulation (Bosello et al. 2016), a drop in pesticide use of about 10-12% can be achieved through gradual introduction of a 50% pesticide tax (see Figure 8). The range of the results reflects three scenarios differentiated by the use of pesticide tax revenue (reduction of labour taxation, reduction of corporate income tax (CIT), reduction of VAT). In contrast, a simulation with the ICES model resulted in a much more limited impact of the tax on the use of chemical products in agriculture: Merely a drop in pesticide use of 0.1% in 2030 and 0.05% in 2050 were computed. The reason for the difference between the two models is that ICES features a much smaller substitutability of chemicals with other inputs in agriculture.

Figure 8. Change in the use of pesticides in different scenarios



Source: MEWA model simulations

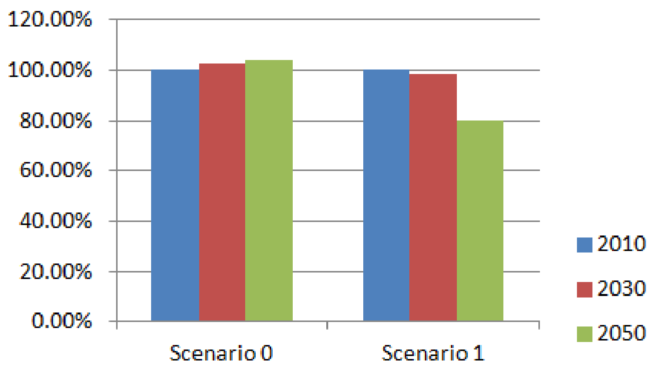
Further factors that enhance biodiversity are the intended protection of sensitive habitats and the promotion of more environmentally friendly farming practices (achieved through the revision of the CAP, promotion of PES programmes) (Nesbit et al. 2015).

Target: No region in the world should experience water stress

The land policy mix is expected to have a positive effect on freshwater resources, as each single instrument of the mix impacts positively on water quality and/or quantity. Therefore it will likely contribute to the target.

For instance, information campaigns will affect water use if they are very effective at changing diets and reducing food waste (Ekvall et al. 2016). More specifically, radically reducing the excess intake of protein until the year 2050 can reduce water use by 20% compared to the current level, even though the European population is expected to grow (see Figure 9 below).

Figure 9: Freshwater Consumption without policy (scenario 0) and with information campaign (scenario 1); normalised to 2010 Values.



This 20% reduction in water use in food production is likely to contribute to achieving the DYNAMIX target that no region should experience water stress. However, since the applied model does not distinguish between different regions, it is not possible to conclude on whether the 20% reduction in the overall food production is sufficient to eliminate regional water stress, or even if it is an important step towards that target.

Apart from reducing the freshwater need for agricultural production, the policy mix enhances water quality. The revision of the CAP, the promotion of PES programmes and the measures limiting nitrogen emissions will result in a reduced use of inorganic fertiliser and a more targeted use of fertilisers in general. In combination with the reduced pesticide use, this can be expected to lead to a significant reduction in negative impacts of the agriculture industry on water quality, and therefore on water availability. This may, in turn, depending on local circumstances, reduce the pressure generated by water abstraction demands on sensitive habitats.

A further DYNAMIX target is to achieve an 80% reduction in consumption of virgin metals by 2050 through increasing dematerialisation and fostering a circular economy. The mix is not likely to contribute to this target. A small reduction in the extraction of raw materials can be expected to be achieved through it. In particular, an improved efficiency of inorganic fertiliser use is expected (through the revision of the CAP, measures limiting nitrogen emissions and through the information campaign). This would reduce the consumption of phosphorus and potassium, as well as the raw materials associated to the production and transport of mineral fertilisers.

3.1.2 Metals and materials policy mix[16]

The metals policy mix was developed to tackle environmental goals, and naturally does have generally positive environmental effects. However, as the instruments are mainly on a comprehensive level and the mix builds strongly on synergies between policies, the effects are difficult to access. Individual policies have usually only a modest impact, and often limited preliminary scientific work exists to draw from. The qualitative and quantitative analysis undertaken, however, provides valuable insights on the effects of the policy mix as a whole. The policy mixes developed in DYNAMIX are ambitious or even visionary. Some of the proposed instruments could not be implemented today, but must be prepared using other instruments in a roadmapping process, leading to different socio-economic paradigms. This system change provided a challenge to modelling the policy mix: macroeconomic models (such as the Intertemporal Computable Equilibrium System [ICES]) are set up to function in a certain economic and technological structure, so modelling structural changes is limited.

Broadly speaking, the policy mix will contribute to the goal of a steep reduction of virgin metals and materials use by:

a) Increasing the price of materials and shifting taxation from labour to materials;
b) Reducing material demand by fostering the efficient use of goods and a shift to services;
c) Increasing resource efficiency by investing in technological advances;
d) Improving repairability, longevity and material efficiency through product standards.

The policy mix will have positive effects on a range of environmental impacts, such as the reduction of greenhouse gases, but in the following section we will focus on the main target, reducing metals and materials use.

[16] This section is based on and adapted from Langsdorf (2016).

Target: increasing dematerialisation and fostering a circular economy to achieve a 80% reduction in consumption of virgin metals by 2050

The metals policy mix will contribute to this target, but the effect for different resources will differ. The two measures of the green fiscal reform, the *materials tax* and the *IET&F*, are likely to have a strong positive environmental effect. The quantitative assessments (see chapter 3.2, Economic impacts) shows a significant reduction in materials use under the IET&F. However, within Europe, the IET&F will mainly help reducing the extraction of bulk materials while other mining will most likely not be majorly affected, as Europe's mining industry is small.

The effects of the *materials tax* are difficult to assess and might differ strongly between materials. For some materials, limited price elasticity has been observed in the past, but the materials tax planned as part of the policy mix is quite high and has never been tested before. Results regarding quantitative effects differ strongly between the models, but in one case a very positive effect of up to 63% material efficiency gains has been calculated (Macroeconomic Mitigation Option Model [MEMO II]) (Bosello et al. 2016). While the results of the quantitative modelling with ICES of the materials tax also show that the instrument will have a reducing effect (compared to a baseline) on a number of sectors (oil products, metals, minerals, construction and manufacturing), the overall results are less positive: both resource depletion and environmental impacts will be greater in 2040 than in 2007 in the EU according to the ICES model (Ekvall et al. 2016).

Product standards will also contribute to the target, but there is a high range of possible impacts, depending on the standards set and the volume of products. Product standards could encompass a number of parameters, including reusability, recyclability and recovery rates or recycled content. It is foreseen in the mix to start with few products and gradually increase the number of products and the standards. A good option to start would be water piping, which was also assessed: a shift from copper water pipes to polymer water pipes (PEX) was modelled. PEX piping systems showed better environmental performance (i.e. with regards to abiotic depletion and global warming). While the effect of that single measure is naturally small (less than 1% of the targeted 80% reduction of the metals ore use), a larger number of product standards could cumulate higher effects. However, as product standards increase, so does the administrative burden on the government and business side (i.e. continuous adaptation of the standard to new technological advances, monitoring and enforcement, knowledge building). Standards are especially helpful where a continuous market failure persists (material prices do not reflect the negative externalities).

Setting the standards requires *research and development (R&D)* in technical feasibility, measuring and data provision. But R&D is also necessary to achieve the technological advances in all other relevant resource fields: i.e. material efficiency, recycling, substitution. The potential may be huge: according to one author 80% of a product's environmental impact is predestined by design (House of Lords 2008), but effects are almost impossible to predict. As an example for the effects of increased R&D the improved dismantling of cars and light trucks was modelled. Under the assumption that improved dismantling of cars would reduce the quantity of copper cables etc. in the steel scrap by 75%, copper recovery would increase by almost 250 kt/year. In mining copper mines with a 0.5% ore grade this corresponds to 50 Mt Raw Materials Equivalents per year. The RMC of copper in Europe is around 150 Mt/year (et al. 2014b). Furthermore, steel scrap from the vehicles would be less contaminated (with copper) thus also leading to a reduction in virgin steel (50 Mt/year) (Ekvall et al. 2016). While modelling relied on assumptions and crude data and therefore results may be overly positive; it can still be assumed that the positive effect would be significant. Despite these positive results, any policy mix must take into account that an increase in efficiency may lead to rebound effects, rather than reducing environmental effects.

The effect of *sharing systems* is yet to be fully analysed. Some studies indicate steep reductions of virgin metals use, as they expect the number of products to go down significantly. But results differ widely, according to two studies car sharing schemes replace 4-12.8 private cars (Bundesverband CarSharing).Furthermore little evidence exists on possible negative side-effects, for example on where the money saved by car-sharing is spent (Gunter 2014).

3.1.3 Overarching policy mix[17]

The overarching policy mix can be considered as having positive **environmental effects** because in combination the eight policy instruments will

a) Increase prices for use of materials and material-intensive products as well as for waste incineration and landfilling;
b) Increase the availability and affordability of less material-intense and more climate-friendly products and services;
c) Help integrate resource efficiency into product design through expanding EPR systems to additional waste streams (e.g. waste tyres, waste oils); and
d) Provide enabling frameworks for reducing material consumption in businesses through skill enhancement programmes, and among households via encouraging the reduction of working hours, restricting consumption-fuelling advertising and supporting local service exchange through local currencies (Nesbit et al. 2015).

Through these mechanisms, the overarching policy mix will likely contribute to increasing dematerialisation and decarbonisation and to fostering a circular economy. Furthermore, referring back to the vision underlying the policy mix, the instrument mix can be expected to improve efficiency and circularity in the economy.

Benchmarked against achieving the DYNAMIX environmental key targets, the policy mix will, with great likelihood, contribute to the following two targets.

Target I: Reducing consumption of virgin metals by 80%, compared to 2010 levels and measured as raw material consumption (RMC).

Although no exact level of contribution to this target can be given, findings for several instruments of the overarching policy mix indicate a great likelihood of contributing to achieving it. For instance, the instrument *boosting EPR* could effectively reduce the need for virgin materials. The effects of a full implementation of the WEEE Directive were estimated to reduce the need for extraction of lead by 131-340 kilotonnes per year in the EU (Arcadis et al. 2008).

In addition, the instrument *reducing VAT rates* for environmentally friendly and eco-labelled products could lead to material savings of more than half a million tonnes in the EU-25, assuming a market share of eco-labelled products of 5% (AEA Technology 2004).[18] Furthermore, a combined virgin ma-

[17] This section is based on and adapted from Hirschnitz-Garbers (2016).
[18] The products covered in the study were those product groups where ecolabels had already been awarded in 2004, i.e.: copying and graphic paper, tissue paper, cleaners for sanitary facilities, all-purpose cleaners, detergents for dishwashers, hand dishwashing detergents, laundry detergents,

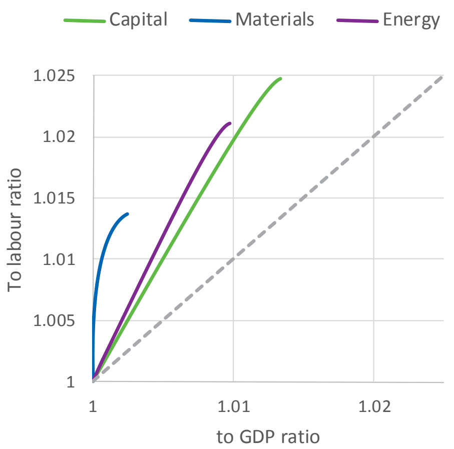
terial and landfilling tax, as proposed in the Circular Economy Tax Trio, could be expected to have effects similar to those of the UK aggregates tax that was combined with a landfill tax. Linked to this taxation, the use of primary aggregates in the UK was found to decline from some 260 million tonnes (Mt) in 1990 to around 146 Mt in 2011 (BGS 2013; MPA 2012). Combining the tax with a progressive landfill tax appears to have had positive effects on the use of recycled materials, which increased from 10 Mt in 1990 to 52 Mt in 2008 (BDS 2009).

The instrument *Labour market reform fostering a shift from consumption to leisure* will lead to a decline in labour supply (see below under Socio-Economic Impacts). As linked to declining labour supply, the price of labour (wages) will increase, some substitution of labour by capital, energy and materials will increase, hence increasing the capital, energy and materials-to-labour ratios (see Table 3 and Figure 10 below). However, as the economy will produce less goods to be consumed, a reduction in the use of energy and materials will occur in the long run (-2.5% for materials use and -2.0% for energy use).

Table 3: Change in energy and material intensity as a result of consumption to leisure shift, changes 2020-2050 to baseline

	2020	2030	2040	2050
Energy use	-0.5%	-1.0%	-1.6%	-2.0%
Materials use	-0.8%	-1.5%	-2.1%	-2.5%
Energy intensity	0.5%	0.8%	0.9%	1.0%
Materials intensity	0.0%	0.1%	0.2%	0.2%

Figure 10: Change in capital, materials and energy-to GDP and to labour ratio (2015=1)



Source: MEWA model simulations

Model simulations for the instrument *Circular Economy Tax Trio* indicate that the policy instrument will have marginal positive effects on material intensity (decrease by about 0.1%, see Table 4), meaning that the decrease in material consumption due to improved efficiency will be fully offset by the proportional increase in the production volume – hence highlighting a likelihood for economy-wide rebound effects.

Table 4: Potential effects of the Circular Economy Tax Trio on material efficiency, changes 2020-2050 to baseline; MEWA model simulations

	2020	2030	2040	2050
Consumption	0.03%	0.05%	0.06%	0.08%
Material use	-0.02%	-0.01%	-0.01%	0.00%
Material intensity	-0.06%	-0.07%	-0.08%	-0.09%

Another simulation model used – the MEMO II model – yields a slightly higher material efficiency

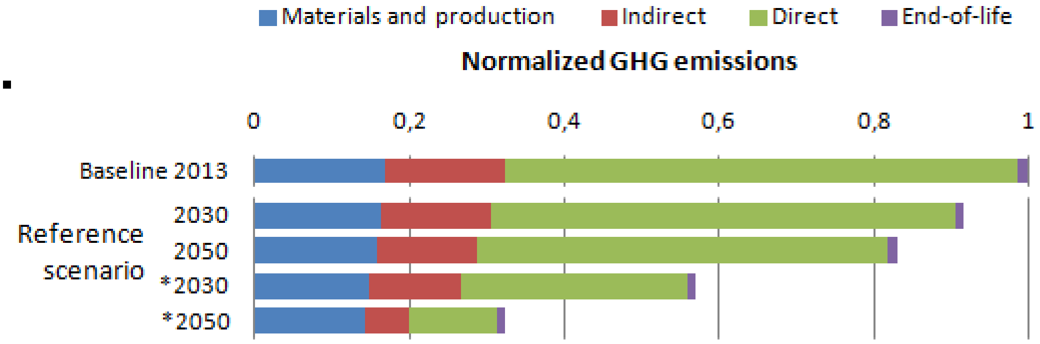
washing machines, dishwashers, refrigerators, televisions, personal computers, laptop computers, light bulbs, indoor paints and varnishes, hard floor coverings, textiles, and vacuum cleaners.

increase of around 1.1% by 2030 and 1.5% by 2050.

Target II: Limiting annual per capita greenhouse gas (GHG) emissions to 2 tons of CO_2 equivalent.

Although no exact level of contribution to this target can be given, very likely the overarching policy mix contributes towards achieving it. For instance, introducing an *EU-wide feebate scheme* on passenger cars could reduce life-cycle CO_2-emissions of the EU passenger car fleet by more than 60% by 2050 compared to 2013 levels (see Figure 11 below).

Figure 11: Normalised emissions of EU passenger car fleet in CO_2-equivalents



*** with EU-wide feebate scheme on cars implemented; Ekvall et al. (2016)**

This effect stems largely from incentivising an increase in the share of hybrid and electric vehicles as well as smaller cars in the EU passenger car fleet. Car size is one important factor because a) less material is needed to manufacture small cars, thus reducing the emissions during materials provision and car production, and b) small cars require less fuel to drive, thus emitting less CO_2 per kilometre than larger cars. However, the choice of mobility technology (hybrid and electric vehicles rather than integrated combustion engines) has a much greater effect on GHG emission reduction than car size.

Furthermore, also the indirect emissions of the car fleet, i.e. emissions from producing fuel/diesel and electricity for powering the cars, decline, because the feebate incentivises not only shifts to smaller cars needing less fuel/diesel production, but also making electric vehicles more efficient, hence needing relatively less electricity production. Potential rebound effects of an overall increasing size of the car fleet or more kilometres being driven with more efficient cars could counteract this emission saving effect (Nesbit et al. 2015) – but this could not be assessed with the models used within the project.

Other instruments of the overarching policy mix could complement the effects of reducing CO_2 emissions. For instance, the instrument *Labour market reform fostering a shift from consumption to leisure* could reduce work-related energy consumption – although this depends on the kind of leisure activities undertaken. A study for the UK finds the carbon footprint of leisure activities to be on average around 17% lower than the average for all other activities (Druckman et al. 2012). For Sweden, a decrease in work time by 1 % was estimated to reduce energy use and GHG emissions by about 0.8 % - and even when accounting for different energy intense activities conducted during increased leisure time, the emission reduction effect due to the income effect of reduced working time was greater (Nässén and Larsson 2010).

Against these assessments, we consider a positive effect of the overarching policy mix and hence a contribution to achieving the first two DYNAMIX key environmental targets very likely.

Due to the policy mix' focus on consumption – by businesses and households – of materials, products and services, the overarching policy mix likely has only limited, but rather positive effects on the other three DYNAMIX key targets (see Table 5 below).

Table 5: Potential contributions of the overarching policy mix on achieving the DYNAMIX targets

DYNAMIX environmental key target for the EU for 2050	Contribution of the overarching policy mix
I. Reducing consumption of virgin metals by 80%, compared to 2010	Very likely positive effects and contributing to achieving the target, e.g. via *boosting EPR schemes*, *Reduced VAT rates* and *Labour market reform fostering a shift from consumption to leisure*
II. Limiting annual per capita greenhouse gas (GHG) emissions to 2 tons of CO_2 equivalent.	Very likely positive effects and contributing to achieving the target, e.g. via *EU-wide introduction of feebate schemes* and *Labour market reform fostering a shift from consumption to leisure*
III. Reducing consumption of arable land to reach zero net demand of non-EU arable land.	Likely somewhat contributing to achieving the target through • reducing the need for (additional) extraction or landfill sites via the *Circular Economy Tax Trio* • encouraging more small-scale (urban gardening) food production in households' leisure time via *Labour market reform fostering a shift from consumption to leisure*
IV. Reducing nitrogen and phosphorus surpluses in the EU to levels that can be achieved by best available techniques.	Likely limited contribution to achieving the target through • encouraging more small-scale (urban gardening) food production in households' leisure time via *Labour market reform fostering a shift from consumption to leisure*
V. Managing freshwater use so that no region experiences water stress	Likely very limited contribution to achieving the target through • reducing water needs for mining via *Circular Economy Tax Trio*

Hence, although the assessments could not provide any quantification of the extent to which the policy mix can help achieving the DYNAMIX key targets, a positive contribution seems very likely. However, potentially negative side-effects of the policy instruments might prevent this policy mix from being implemented or might reduce its effectiveness – so that the above potential environmental effects may not occur or be different. In this context, socio-economic impacts as well as issues of legal feasibility and public acceptability of the mix must be considered.

3.2 Side-effects

Although the assessments could not provide any quantification of the extent to which the policy mixes can help achieving the DYNAMIX key targets, a positive contribution seems very likely. However, potentially negative side-effects of the policy instruments proposed might prevent the policy mixes from being implemented or might reduce its effectiveness – so that the above potential environmental impacts may not occur or be different. In this context, socio-economic impacts as well as issues of legal feasibility and public acceptability of the mix must be considered.

3.2.1 Land policy mix[19]

Socio-economic impacts

One positive side effect of the policy mix is its overall favourable impact on human health. This is mainly due to a reduction of harmful pollution as well as the healthier diets.

Looking at the land policy mix from an economic perspective, an important point is that the mix is likely to increase prices of agricultural outputs. This could encourage the desired shift in diets as well as the avoidance of food waste – and to that extent appears at first glance to be coherent with the aims of the policy mix.

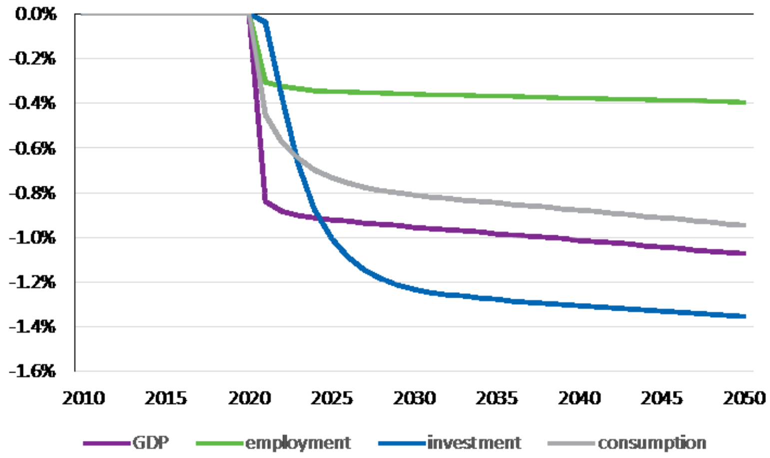
However, the increase in prices also has negative side effects. Most importantly, it poses different health risks, and a risk to social equity. As the poorest households spend the highest share of their income on food, they will be most affected by price increases caused by the policy mix. This could also increase the risk of malnutrition for certain groups of society, in particular through inadequate consumption of key micronutrients by children. Apart from the general price increases associated to the policy mix, the VAT on meat products in particular will disproportionately affect low-income households. Here, the food redistribution programmes have the potential to offset this effect, at least in part. Next, since there are no policies targeted on seafood and fish, the consumption of these will presumably increase. Considering the global problem of overfishing, this could be seen as a rather critical side effect.

Regarding employment, the effects for most of the production policies are uncertain. For three policies (revision of the CAP, measures limiting nitrogen as well as the improved management of pesticides) a likely neutral or rather negative impact on the labour market was assessed, dependent on specific provisions and adaptability of farmers to the new requirements. In contrast, the promotion of PES is expected to have positive labour market effects in rural areas, as new employment opportunities may be unlocked.

On the consumption side, a rather negative impact on the labour market is expected from the VAT on meat products: The shift in consumption expenditure will require a reallocation of labour across the economy, which is likely to decrease employment in the short-term. A simulation exercise scrutinised the macroeconomic effect of the VAT on meat products on employment, as well as on GDP, investments and overall consumption. The results indicate that the impact would be very low (see Figure 12) and arguably on an acceptable level.

[19] This section is based on and adapted from Hinzmann (2016).

Figure 12. VAT on meat products: Change in macroeconomic variables in comparison to the baseline



Source: MEWA model simulations

Public acceptability

Public acceptability differs across the instruments contained in the policy mix. While most instruments can be expected to receive support by the public, food redistribution programmes have the potential to evoke some resistance and the VAT on meat products is likely to be strongly opposed.

Regarding the production side, it has been assessed as unlikely that the production policies in the mix would be publically contended. Overall, the EU population is highly supportive of the objective of CAP and the objectives of these policies. It is likely that the details of the policies will be contested between the agricultural sector and the relevant public authorities, but it seems unlikely that this would be discussed widely or within public discourse. This finding, however, contrasts with experience of previous attempts to introduce an effective environmental component to the CAP, and should be treated with caution.

Regarding the consumption side, it is unlikely that policies focusing on information campaigns relating to food waste or efforts to strengthen food donation and reduce waste will encounter significant opposition. In fact, the public has frequently come out in support of food waste redistribution efforts and against efforts to cut funding to these programmes such as in France with the Fund for European Aid to the Most Deprived. However, should the proposed measures threaten to increase living costs or significantly reduce the consumer's right to shop freely and throw unwanted food away, it is possible that a coalition of interest could form to lobby against the measures. Therefore the measure needs to be designed with care to ensure the maximum positive impact.

Finally, removing VAT exemptions on meat products would likely generate considerable public discourse and resistance among many, often rooted in cultural relationships with meat. The meat sector would be likely to mount concerted lobbying efforts to highlight among the public the drawbacks of the policy. These would include fairness concerns, border issues and competitiveness issues. Therefore, the measure needs to be mitigated and implemented with the investment of political capital.

Legal assessment

As regards legal feasibility, some of the instruments contained in the overarching policy mix could be in potential conflict with WTO law or the EU Treaty. The most problematic instrument appears to be the VAT on meat products.

a) At EU level, any harmonisation of legislation concerning turnover taxes, excise duties and other forms of indirect taxation would be subject to Article 113 of the Treaty on the Functioning of the European Union (TFEU) and would require unanimity by the Council. For the VAT on meat products, this is unlikely to be achieved, due to the expected resistance of some Member States. Furthermore, it would need to be "necessary to ensure the establishment and the functioning of the internal market and to avoid distortion of competition" (Article 113 TFEU), which is doubtful and still needs to be discussed. Recourse to Article 115 TFEU (approximation of laws) is not permitted. The instrument's feasibility is thus doubtful. Regarding WTO law, the national-treatment principle does not seem to be infringed as domestic products as well as imports are taxed without making any difference. However, exported meat is not subject to the tax. The intended exemption therefore needs to be justified.

b) Regarding the measures aimed at limiting nitrogen emissions, the compatibility of a fertiliser tax with the General Agreement on Tariffs and Trade (GATT) is questionable.

c) Similarly, the compatibility with the GATT is questionable for taxation elements within the measures for improved pesticide management, such as a volume tax on active ingredients in pesticides placed on the market.

d) Regarding food redistribution programmes, it is important to note that the imposition of VAT on food donation in some Member States is a difficult area. Terminology in legal texts varies, such that the value of food may be considered low or zero at time of donation, VAT may be 'abandoned', or 'exempted'. This issue is both controversial and lacks clarity. (Lucha and Roberts 2015)

3.2.2 Metals and materials policy mix[20]

Green fiscal reforms (GFR) have been found to be effective[21] in a great number of studies; for example with regards to emissions reductions one study finds a positive environmental effect in 95% of the simulated cases (Gago et al. 2013). In theory, GFR are also an efficient instrument. However, apart from the real world limitations to theory (revenue shifts, associated management costs, unfavourable layering with existing measures, etc.), there exists a trade-off between efficiency and equity. GFR are (theoretically) revenue neutral, but do affect some sectors more than others. While pushing for a shift away from polluting industries is a goal of a GFR, this may still create temporary hardships for affected workers and sometimes entire regions. Furthermore, many studies show a rise in regressivity of GFR. As poorer households spend more of their income on consumption, they get taxed relatively higher than richer households, leading to problematic distributional effects.

The analysis of the specific instruments – *internalisation of external environmental costs* – foresees positive environmental impacts, but the economic analysis shows a more complex

[20] This section is based on and adapted from Langsdorf (2016).

[21] *Effectiveness* defined as the capability of an instrument or mix to reach the objective.

picture. Taxing a very wide range of products may lead to a decrease in GDP, especially as the substitution from materials to labour may not always be possible. Furthermore the overlapping of distinct taxes carries an economic risk and the quantification of the externalities, and subsequently the taxes, is a challenge. As the instrument would be quite comprehensive, a strong impact on the competitiveness and income distribution (due to the tax regression) is likely. The former may be healed with sector-specific GFR, which would provide more funds for the transition of the targeted sectors. Some studies also expect an inflationary effect (Gago et al. 2013), which negatively affects groups with fixed incomes. The main critique of the *materials tax* from the qualitative economic assessment is its similarity with the IET&F, which is considered an inefficient approach.

The different models used for the quantitative assessment yield differing results. The quantitative economic assessment with the MEWA (Material Energy Waste and Agriculture) model indicates that the *materials tax* leads to significant macroeconomic benefits by 2050. According to the assessment, GDP increases by 5.8% and employment by 7.2%. Materials demand decreases by more than 13% below the baseline scenario. However, these positive effects only manifest if significant material efficiency gains can be achieved – so the accompanying increase in R&D is key for sustaining economic growth – and if labour taxation is reduced correspondingly. If instead of reducing labour taxation, transfers are increased, GDP and employment will decrease according to the assessment (Bosello et al. 2016).

Table 6: GDP and employment impacts of material taxation in the EU in various scenarios according to the MEWA model.

Scenario	GDP		Employment	
	2030	2050	2030	2050
Base case: reduced labour taxation, material efficiency increase via private R&D	0.92%	5.81%	1.11%	7.16%
Alternative 1: no material efficiency increase via private R&D	0.11%	-1.80%	0.14%	0.14%
Alternative 2: increased transfers instead of reduced labour taxation	-0.62%	-6.55%	-0.05%	-1.11%

Source: MEWA model simulations

For modelling the *IET&F*, a flat rate tax of 35% for externalities (as proposed in the policy mix) on all non-service sectors was assumed in the MEWA model. A substantial amount of the revenues were used to decrease taxes on labour (defined as the sum of personal income tax and social security contributions): from 30% to 4.4%. The revenues were also used to reduce VAT in the model. The externality tax paired with the reduction in the VAT levels impacts GDP slightly positively. In contrast, in the MEMO II[22] model IET&F has a reducing effect on GDP

[22] It is important to note that due to the differing model needs the assumptions differed in important respects, which partly explains the differing assessment results: In the simulations of the material tax and IET&F with the MEMOII model it was assumed that 50% of the tax revenue is spent on reducing labour tax, and 50% is transferred as a lump sum to the households. This split was made because lump sum transfer/tax is not distorting in that model, whereas labour tax is, and its decrease causes an increase of labour. The ICES model used a 100% lump sum transfer closure. In MEWA 100% of the

(-5.8% in case of a flat rate tax). The revenue from the tax is approx. 8.5% of GDP. Furthermore, a drop in investment in physical capital can be observed until the tax rate has stabilised in 2050 in MEMO II. Due to a lack of innovation, the IET&F does not even lead to a significant reduction of materials use, even though a switch to services can be noted. This rather negative assessment may underline the importance to link the instrument to a strong R&D instrument.

Further conclusions can be drawn from the assessment of the materials tax with MEMO II, in which it was also assumed that 50% of the revenues will be used to reduce labour taxes. Here a more positive picture comes about: GDP is 1.9% higher than in the baseline scenario in 2050 and an initial drop in investment rebounds. Employment increases by approximately 6.2% in 2050 and the tax revenue is with 10.7% of GDP slightly higher than for the IET&F instrument. The final 200% tax rate in 2050 will reduce materials use strongly (up to 63%), contributing strongly towards the 80% reduction goal. The more positive assessment of the materials tax in comparison to the IET&F is mainly due to additional investments in more resource efficient technologies (Bosello et al. 2016).[23] The assessment of the materials tax with the ICES (Intertemporal Computable Equilibrium System) model calculates a decreasing GDP (-5% in 2050), whereby individual countries are affected differently. Material intensive industries are naturally affected strongest by the tax, but a cascading effect to energy sectors and construction is observed in ICES. Material intensity declines by ~ 12% in 2050.

Increased spending on *R&D* can lead to technological innovation, but results are unpredictable and technological breakthroughs occur erratically. Research has shown that companies invest less in R&D than would be socially desirable, which justifies public support for R&D (Arrow 1962). This underinvestment can be explained by the fact that R&D creates positive externalities: innovative companies create a benefit that can be used by other companies. While the copying of more advanced technology by other firms augments the positive effect for the environment as a whole, it leads to a competitive disadvantage for the investing firm, as it bore the research costs (Popp et al. 2009). By inversion of the argument research policy needs to foster the diffusion and mass adoption of better technologies to enhance the positive environmental effect. The combination of R&D policies and appropriate policy measures is important for both the adoption of technologies and the effectiveness of environmental and innovation policies.

From an economic standpoint, technological innovation will shape the cost functions of products. But due to the reasons mentioned above companies will usually underinvest in R&D. Government R&D helps to compensate for this gap and is especially important for basic R&D which has uncertain and not immediately marketable results. The very rough quantitative assessment of increased R&D indicates that the measure will significantly increase European

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environmental tax revenue was spent on labour tax reduction. This is a significant source of differences in results. An additional simulation in MEMO II with a 100% labour tax decrease turned up more optimistic results for GDP and employment developments.

[23] Why the materials tax raises innovation and the IET&F does not in MEMO II modelling: The *materials tax* raises the price of the intermediate input for firms. To offset this effect, they invest in material efficiency. The *IET&F* were modelled as a tax on the output of the industry sector. This leads to an increase in the price for goods, which in turn decreases demand. For the firm no clear link between price (tax) signal and the material input arises. Therefore the firm has no incentive to invest in material efficiency in the model logic. The main difference between these simulations is the placement of the price signal brought about by the two taxes. It must be noted that the IET&F could also be designed in a way that firms have incentives to invest in efficiency.

GDP (~14%) and materials efficiency (~10%), in the long term, advancing technologies and encouraging private companies to increase their R&D investment. But the efficiency gains will be consumed by the rebound effect – in the above calculations materials consumption will rise 4% and emissions will also rise (Bosello et al. 2016). These mechanisms make increasing R&D an important component of the policy mix, but in order to not increase environmental impact, it must be connected with the above measures.

The economic analysis of environmental policies deems *product standards*, as a command-and-control instrument, inferior to market-based instruments. If the objective is to reach a specific (technological) standard, then a regulation may be a suitable instrument, especially as product standards are simple to design. However, from an economics point of view, more generic environmental endpoints such as the reduction of materials use would be better served by a materials tax. Additionally, market-based instruments require less monitoring and enforcement efforts (Popp et al. 2009).

The *stimulation of sharing systems* is seen as an instrument with limited effectiveness to reduce environmental pressures, as the amount of materials used in the typical sharing sectors is not very high. Plus, with regards to the most relevant sharing system – car sharing – the impact on fuel consumption and GHG emissions is not yet clear as people who never owned a car may now use sharing systems. At the same time, this effect contributes to more equality. However, until now only limited research has been undertaken and the effect may become more positive if the sharing systems foster a value shift away from the ownership paradigm.

Nevertheless, it is questioned if public support for sharing systems is needed, as in recent years sharing systems flourished without state intervention. The assessment therefore suggests dropping this instrument in order to not misallocate funds that would better be used elsewhere. If support is given, the economic assessment favours support to private firms running sharing schemes. As the design of the sharing system is important for its efficiency, a low governance level (to address the local barriers to sharing schemes) should be in charge.

In summary, the broad range of instruments in the mix ensures no major aspect is left out, and the supporting tools “removal of EHS” and information campaigns round off the mix. On the downside, the overlapping of the IET&F and the materials tax is inefficient, and both should be integrated, with the IET&F as the starting point.

Social impacts[24]

The social impact assessment focussed (after a selection process) on three key social impacts, which also have interlinkages: labour market impacts, health impacts and social inclusion impacts.

The metals policy mix will have strong social impacts, especially regarding health and safety issues. All main instruments with the exception of R&D were identified as having potentially significant impacts on health.

The analysis of the **labour market impacts** focussed on “job creation and destruction” and the “changing nature of jobs.” The main impacts of the mix on the labour market result from the *IET&F* and the *materials tax*. Taxing pollution and resource use will impact industries, especially manufacturing where metal consumption is central. The decrease in market de-

[24] The findings presented in this section are based on Bukowski, M., Śniegocki, A., Gąska, J., Trzeciakowski, R., and Pongiglione, F. (2015). Report on qualitative assessment of social impacts. DYNAMIX project deliverable D 5.3. Warsaw, Poland: WISE Institute.

mand for material intensive goods will likely decrease employment in the short term. Decreasing labour taxation provides fiscal incentives for labour reallocation; also, the gradual strengthening of price signals allows companies and workers to prepare the transition. The employments structure should shift to services.

The promotion of sharing systems is not expected to affect the labour market strongly. Sharing systems may, over the long term, affect the number of jobs in manufacturing (if the systems are very successful and less products are needed to satisfy demand), but due to the high level of automation this effect will remain small, if it occurs at all. On the other hand, employment may increase in the service sector, as sharing systems are relatively labour intensive (albeit many successful sharing systems are highly digitalised and thus not as labour intensive as classic rental systems). The impact on the labour market is likely to be small but positive. As shared items are used more efficiently, prices should go down and access to services increased. Product standards will not affect the labour market strongly as a whole, but may have strong local effects if companies or regions depend highly on an affected product.

Investing in *R&D* may have a significant impact, but outcomes are uncertain and effects would come with a time lag. If breakthroughs occur, new opportunities arise; but skill mismatches are likely, as reallocations of labour have to be undergone.

Public health impacts were assessed through the impact on production and consumption, especially the resulting changes in pollution and dietary patterns. If successfully improving resource efficiency, the metals mix should lower industrial pollution. In the wake of this, the reduction of air pollutants will have positive impacts on health. Nevertheless, life cycle emissions should be monitored, as also renewable technologies emit some pollutants (Bruckner et al. 2014). Furthermore a reduction in materials use will reduce transport and air pollution from landfilling.

IET&F are among the strongest instruments to tackle negative health impacts. The policy instrument intends to increase taxes and fees to equal 100% of the external costs – including health costs. Thus a price signal will be provided to switch to less deleterious alternatives. The *materials tax* will, by design, target the material consumption of manufacturing and construction industry, leading to emissions reductions in industries that produce materials, but also in the manufacturing industries itself. These industries are also responsible for very large pollutant emissions. The *promotion of sharing systems* should also have a small positive effect – due to the more efficient use of goods and to the nature of some of the sharing systems (e.g. bike sharing). Increasing recycling rates and resource efficiency through innovations (i.e. *R&D* increase) and higher *product standards* will also have (small) positive health effects.

Impacts on **social inclusion** were assessed via the distributive effects. Decoupling policies will often have a progressive effect on poorer households, because decoupling should make economies less prone to shocks (which poorer households cannot prepare for) and also the reduced disaster risk benefits more vulnerable households and groups. Increases in market prices for resource intensive goods will affect poorer households disproportionally. Households with low GDP per capita spend a larger share of their income on resource intensive goods and food, so rising prices may even negatively affect nutrition in these households. These segments of society are also more likely to be affected by labour reallocation and a reduction in wages brought about by decreasing labour productivity. On the other hand, new job opportunities will arise in the circular economy, and a decrease in labour taxes will increase the disposable income. Of all the instruments, the green fiscal reform is expected to have the strongest impact. The reduction in labour taxes which is part of the *GFR* should increase employment, but the taxation of emissions (*IET&F*) as well as the *materials tax* will lead to higher prices of final goods, thus putting more pressure on poorer households. Also, the producers may shift the higher costs on to their workers, which would also affect certain groups of workers.

The *promotion of sharing systems* should have a significant positive effect on social inclusion. As sharing systems increase the availability of goods and services at lower prices (due to efficiency gains), more people gain access.

Assessing the effects of *increasing R&D* always involves an element of uncertainty. Historically, technological progress has increased labour productivity and, as a consequence, living standards (especially those of low skilled workers). If these trends remain is unclear, effects in the short and medium term are ambiguous: benefits from increased productivity may not be distributed evenly and R&D may further the technological development in such a way that low-skilled jobs become obsolete, especially through automation and digitalisation. Also, the budget spent for R&D cannot be spent elsewhere.

Legal feasibility[25]

According to a first assessment, the instruments seem to be in accordance with World Trade Organisation (WTO) law, as the indirect taxes foreseen in the mix (*materials tax* and *IET&F*) do not discriminate products not produced in the EU, and reverse discrimination (discrimination of own products) is allowed. *Increased R&D* is compatible as the subsidies have “no, or minimal trade-distorting effects”[26] and don’t provide price support to producers. The *promotion of sharing systems* is also compatible, as long as foreign companies can participate and receive the subsidy. *Product standards* are, in the legal sense, a technical regulation under the “Technical Barriers to Trade”[27] (TBT). The standards shall be developed under the International Organization for Standardization (ISO) framework, or subsidiary, under the European Committee for Standardization (CEN) framework. Both frameworks are recognised under the TBT. As the standards shall apply to imported and national goods, no discrimination occurs. The standards have to be notified to the WTO Secretariat at draft stage for conformity assessment.

With regards to EU-law some concerns exist:

a) As the *materials tax* would apply to imported and domestic materials alike when introduced at Member State level, Article 110 of the Treaty on the Functioning of the European Union (TFEU) does not seem to be infringed. However, the harmonisation of such an indirect tax requires a unanimous vote of the Council and the tax must be “necessary to ensure the establishment and the functioning of the internal market and to avoid distortion of competition” (Art. 113 TFEU).

b) The same difficulty as under a) applies to the *IET&F*. Furthermore, with regards to the emissions part of the instrument, it would need to be checked how the instrument would interact with existing EU Emissions Trading and other related existing regulations. From a judicial point of view, IET&F is also too broad to be an “instrument,” more specification would be necessary for a thorough assessment.

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[25] The findings presented in this section are based on Lucha, C. and Roberts, E. (2015).

[26] World Trade Organization. 2016. Agriculture negotiations: Background Fact Sheet. Available at: https://www.wto.org/english/tratop_e/agric_e/agboxes_e.htm.

[27] World Trade Organization. 2016. Technical Information on Technical barriers to trade. Available at: https://www.wto.org/english/tratop_e/tbt_e/tbt_e.htm.

c) While the *promotion of sharing systems* might be a subsidy, it would remain compatible with EU-law provisions if it is covered under the de-minimis rule that is if a single company does not receive over EUR 200,000 in three years. If higher, the Guidelines on environmental and energy aid for 2014-2020 may apply: Measures may be compatible with internal market under Art 107 (3) (c) TFEU if aid is given for environmental protection going beyond Union standards (or in case of lack of such standards). So if the instrument actually leads to a more efficient use of natural resources (this might need to be proven) higher aid might still be compatible with internal market rules. In taking a decision for one of the differing designs of that instrument emphasising the above would be a sensible strategy.

d) The *product standards* as presented in the policy mix seem compatible with Art 34 TFEU (free movement of goods); however, further specification of the design would be needed for a final assessment. The standards would be compatible if the "national provisions restricting or prohibiting certain selling arrangements [do not] hinder trade between Member States, […] so long as those provisions apply to all relevant traders operating within the national territory and so long as they affect in the same manner, […] the marketing of domestic products and of those from other Member States."[28]

For the further development and fine-tuning of this (or other) policy mix(es) from a juridical point of view it is advisable to:

a) Connect the mixes more strongly to the overall objectives (reducing consumption of virgin metals use by 80% while avoiding large increases in the use of other materials or in environmental impacts). Furthermore the connections to the protection of human health and the environment as well as the reduction of energy resources should be demonstrated. High-ranking objectives such as the protection of health and/or environment may legitimise trade distorting instruments;

b) Eliminate any arbitrary or unjustifiable discrimination between countries or disguised restriction on international trade in the design of instruments; and

c) Consider the pursuit of (multilateral) environmental agreements to reach targets.

d) It is advisable (and sometimes required) to notify the European Commission and the WTO Secretariat of planned measures to avoid collisions with trade law.

Public acceptance[29]

Public acceptability of policy instruments is strongly linked to the dominant paradigms in society. Those paradigms are usually very stable and change only slowly through new evidence and experience in public discourse. Nevertheless change does happen and can be fostered through policy mixes and the right sequencing of policies. From a current standpoint, however, the ex-ante assessment expects low public acceptance of:

- The green fiscal reform (GFR) – *internalisation of externalities* and *materials tax* – are expected to be met with resistance. GFR is a confined professional discourse with only the tax component likely to enter the public discourse, and some strong opposing lobby groups (motorists, etc.) exist. Therefore it would be important to capture the benefits in the public debate, and a fair and even imposition of the tax.

[28] Judgment of the Court of 24 November 1993, Criminal proceedings against Bernard Keck and Daniel Mithouard, Joined cases C-267/91 and C-268/91. Furthermore the "Cassis de Dijon" ruling may be applicable. According to this ruling, restrictions can be justified if they serve a purpose which is in the general interest and takes precedence over the requirement of the free movement of goods.

[29] The findings presented in this section are based on Vanner et al. (2015).

- The economic situation, unemployment and public finances are frequently mentioned as the most important issues facing the EU (European Commission 2014). To achieve public acceptability it is, therefore, important that the *materials tax* shall be applied to imported and domestic materials. Any instrument design should ensure the competitiveness of the European industry isn't threatened, in order to ensure public acceptability. Furthermore the revenues shall be "recycled" to those facing the tax as much as possible to retain trust. The (fiscal) benefits of the reform should be communicated clearly.
- Regarding *product standards*, public acceptability is likely to vary strongly between Member States. While in many countries the topic is expected to be un-contentious, there exist some exceptions, such as the UK, which is rather Euro-sceptic. To counter resistance, sequencing of standards – starting with standards that improve the consumer benefit and later introduce standards of sole-environmental benefits – is beneficial. Country tailored implementation timeframes may also affect acceptance positively. More independent technical oversight on standard setting would increase transparency and reduce manufacturers influence on product standard setting.

3.2.3 Overarching policy mix[30]

Socio-economic impacts

From a perspective of socio-economic impacts[31], potentially negative effects of the policy mix (or some of its instruments) on the costs for industries and/or state bodes, on the European labour market (employment effects) and on inequality (distributional effects) may adversely affect the likelihood of the mix being implemented as envisaged. Table 7 below presents both potentially positive and negative socio-economic impacts of the overarching policy mix.

Table 7: Potential budgetary, employment and distributional effects of the instruments of the policy mix

Instrument	Budgetary effects (companies/state bodies)	Employment effects	Distributional effects
(1) Labour market reform fostering a shift from consumption to leisure	If reducing working hours is mandatory: Likely negative effects due to labour productivity reductions Likely greater monitoring and enforcement effort for state bodies	Likely negative effects in case of mandatory changes as mandatory changes would reduce productivity of workers especially among lower qualified work forces could increase lay-offs.	Likely negative in the case of mandatory changes leading to decreased productivity and increased unemployment, affecting less qualified workers most. Likely positive effects in case of voluntary changes (e.g. introduction of voluntary flexible labour market arrangements) due to improved work-life-balance and eased job entry for graduates, young parents and young pensioners

[30] This section is based on and adapted from Hirschnitz-Garbers (2016).
[31] The findings presented in this section are based on Bigano et al. (2015) and Bukowski et al. (2015).

Instrument	Budgetary effects (companies/state bodies)	Employment effects	Distributional effects
(2) Step-by-step restriction of advertisement and marketing	Likely negative due to demand-driven reductions in ROI for the advertising sector Likely greater monitoring and enforcement effort for state bodies	Likely negative effects through (a) direct job loss in the advertising sector and (b) indirectly in the wider economy through potential changes in consumer demand for certain products	Likely negative effects through an increase in unemployment Likely positive effects through less visual pollution, advertising targeted at children and a potential increase in social capital through the reduction of consumerism
(3) Boosting Extended producer responsibility (EPR)	Expanding EPR schemes could suffer from additional administrative effort to monitor and sanction non-compliance (problems of free riding) and hence increased enforcement costs.	Likely small net positive effects due to greater labour-intensity of product design and recycling vs. waste management and incineration	Likely limited effects because while prices for certain products may increase due to EPR fees being added, durability should improve hence reducing the need for (quick) replacing
(4) Circular Economy Tax Trio	Likely small positive effects due to material savings for companies Likely negative effects for the mining sector	Likely small net positive effects due to greater labour-intensity of recycling vs. waste management and incineration Likely negative effects on regional level for economies with larger mining shares in national account	Likely negative effects due to regional unemployment effects for economies with strong mining sectors Likely negative due to regional income effects on poorer households located in countries with low incomes and high rates of landfilling
(5) EU wide introduction of feebate schemes	Managing a fund to ensure budget-neutrality of the feebate schemes (i.e. collecting taxes on non-green products and using this revenue to subsidise the green products in order to avoid the government having to finance the fund itself) is challenging and difficult to achieve due to price elasticities and uncertainty of demand development.	Likely only limited effects because the instruments encourage demand shift within given product categories and thus most labour reallocation should occur within the affected sectors and companies that produce both environmentally advantageous and disadvantageous products and services	Likely negative effects due to issues of affordability for lower income households needing to purchase products receiving a fee

Instrument	Budgetary effects (companies/state bodies)	Employment effects	Distributional effects
(6) Reduced VAT	VAT reductions may increase compliance costs for enterprises and tax authorities		Likely small positive effects because reduced prices may increase affordability of environmentally friendly products
(7) Skill enhancement programme	Likely positive due to a (better) matching between skill needs and skilled labour	Likely positive effects (also potential to mitigate negative effects of other policy mix instruments) as they allow the labour market to (better) adapt to a green(er) economy by improving matching between skill needs and skilling activities. Potential to shorten the process of job searching and of reducing the period of unemployment after a lay-off.	Depending on the design of the programmes likely positive effects because skilling could increase equality of employment opportunities
(8) Support for local currencies	Potentially limited effects due to lower demand for products but greater demand for services in local communities Depending on design of local currency schemes state bodies need to monitor and enforce taxation differences of participants to the local currency schemes	Likely small positive effects as local currencies reduce relative prices of locally produced services, which are in general more labour intensive than the economy on average, and thus increase employment at least locally	Likely positive as community activities are fostered across participants to the local currency schemes

Modelling results for the instruments *Circular Economy Tax Trio* and *Labour market reform fostering a shift from consumption to leisure* provide further detail on potential socio-economic impacts.

Potential socio-economic impacts: Circular Economy Tax Trio

Model simulations for the Circular Economy Tax Trio indicate that macroeconomic variables will change only slightly – depending on the simulation model used either slightly decreasing (MEMO II model) or slightly increasing (MEWA model) (see Table 8 below).

Table 8: Potential effects of the Circular Economy Tax Trio on major macroeconomic variables, changes 2030 and 2050 to baseline

Macroeconomic variable	2030		2050	
	MEWA	MEMO II	MEWA	MEMO II
GDP	0.05%	-0,51%	0.08%	-0,13%
Employment	0.05%	-0,6%	0.06%	-0,15%
Investment	0.07%	-0,64%	0.10%	-0,38%

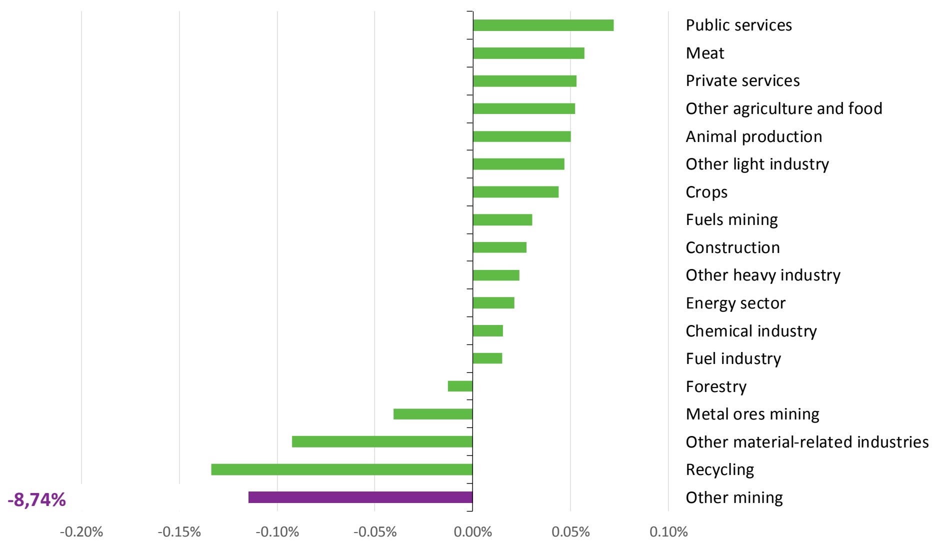
Source: MEWA and MEMO II model simulations

The potential effects are small because (i) the proposed marginal tax rate is relatively small, (ii) taxation is limited to mines located within the EU borders (imports are not taxed) and (iii) in the European economy the mining sector is only small scale. According to MEWA model findings, EU GDP could rise by 0.08% by 2050 due to a small surplus generated through material savings. Employment will also rise (0.06%) because the instrument is thought to increase employment in recycling at the expenses of employment in waste disposal and incineration – the net direct impact on the number of jobs is expected to be positive[32], as recycling is usually more labour-intensive than disposal and incineration (Murray 1999; Goldstein et al. 2011).

Based on MEMO II results GDP will drop by approximately 0.5% around 2030 and by some 0.13% points around 2050. Employment could decrease in a similar order of magnitude. The revenues of the circular economy tax trio are found to be small, amounting to some 0.2% of GDP.

However, from a sectoral perspective, socio-economic impacts of the instrument may be significant. Sectoral production in the mining sector is expected to drop by 9% by 2050 (see Figure 13 below).

Figure 13: Change in the production volume on the sectoral level in 2050



Source: MEWA model simulations

While at the scale of the European economy both the limited share of this sector in the European

[32] However, the total labour market impact depends on the potential for productivity improvements: (a) when previously underutilised potential for the cost-efficient recycling can be released, this will lead to overall increase in labour productivity; (b) when more labour and capital inputs are needed to increase recycling rates then productivity will decrease, with associated negative short-term employment effects (Bukowski et al. 2015).

economy and the ability of other industries to substitute domestic raw materials with cheaper substitutes from import or recycling render potential impacts marginally positive, countries where virgin aggregates make a significant contribution to the national economies might experience significant loss in mining sector production and associated job losses and tax income reductions.

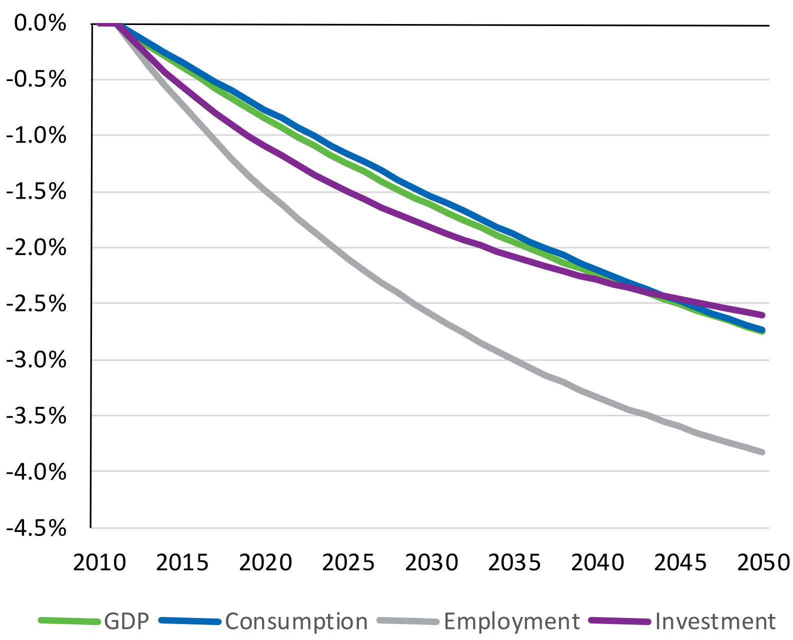
In addition, taxation of relevant municipal services, such as waste management in the Circular Economy Tax Trio, will often mostly affect the poorest households disproportionally (OECD 2008). Significant income differences across the EU may make this problematic in particular for poorer households located in Central and Eastern Europe – not only because of relatively low incomes, but also due to high rates of landfilling requiring households to pay more for the taxed waste management option. This could contribute to unemployment and poverty where taxation reduces jobs not only in the mining sector, but also in other resource-intensive industries based on local raw materials which are expensive to transport.

Therefore the desirable supplement to the policy instrument should take a form of a regional, structural policy that would help affected communities to accommodate and counterbalance the negative consequences of the circular economy tax trio on their labour market and investment perspectives.

Potential socio-economic impacts: Labour market reform fostering a shift from consumption to leisure

Although difficult to model, enabling a shift from consumption to leisure will lead to a decrease in the "motivation" to work and consequently to a decline in labour supply. Along with changes in employment, GDP, consumption and investment levels will fall (see Figure 14 below).

Figure 14: Changes in GDP, consumption, employment and investment related to the consumption to leisure shift.



Source: MEWA model simulations

Furthermore, linked to declining labour supply, the price of labour (wages) will increase by 2.0% by 2050 (Bukowski et al. 2015), leading to some substitution of labour by capital, energy and materials, hence increasing the capital, energy and materials-to-labour ratios (see Table 4 and Figure 5 under

3.1 Potential environmental impacts). Overall, enabling the shift from consumption to leisure will not only lead to some decrease of energy and materials used, but it will also limit the productivity and hamper the competitiveness of the economy. Such change is also difficult to introduce and may require extensive promotional activities to affect individual choices.

Furthermore, the instrument might increase inequalities in case of a mandatory shortening of the work week and increase in statutory holidays. As this will decrease productivity per worker, lay-offs could primarily affect less qualified workers.

However, if the labour market reform measures are voluntary, they will positively impact social inclusion through enabling people to spend more time with their families and facilitate labour market entry for (i) students not having enough time for a full-time job; (ii) parents, who will be able to return to the labour market earlier; and (iii) younger pensioners, who may no longer have the vitality to take a full-time job.

The use of **regulatory instruments** may counteract instrument efficiency and yield inequalities. This is because regulation imposes the same target to heterogeneous actors irrespective of their relative ability to attain it. Thus, regulatory instruments risk not fully tapping the **innovation capacities** of different actors, but in fact only forcing actors to abide by minimum compliance standards. For instance, a forced decrease in working hours in the context of *Labour market reform fostering a shift from consumption to leisure* potentially hits low-income earners hardest. In contrast, voluntary, incentivised shifts towards leisure may appeal to better paid workers and in turn lead to reduced inequalities. Furthermore, when using compulsory standards for the instrument *boosting EPR schemes*, e.g. for product packaging, individual should be prioritised over collective responsibility schemes. Collective schemes may not sufficiently stimulate investments in product design because the collective schemes mutualise costs while complicating an effective internalisation of the increased costs into product prices (BIO by Deloitte et al. (2014).

In this context, market-based instruments (MBIs) are often considered more effective than regulatory instruments, enabling businesses to adapt innovatively at least cost. However, two aspects of the use of MBIs merit attention:

(1) The two MBIs *EU wide introduction of feebate schemes* and *Reduced VAT rates* incentivise the purchase of more resource and energy efficient products and services. Hence, their use could increase the consumption of products and services use in absolute terms and hence contribute to overcompensating the initial savings effect – i.e. **rebound effects** could result. This may happen if, for instance, a reduced VAT rate on products, which fulfil energy efficiency criteria acts as a subsidy to replace products before their end of life by more up-market or larger A-rated products.

(2) **Revenues generated** by MBIs need to be wisely used: for instance, to

a) Pay for subsidies (rebates) granted in order to achieve as much budget-neutrality as possible in *feebate schemes*;
b) Mitigate potential closure of quarries or extraction sites affected by taxation of virgin materials (in *the Circular Economy Tax Trio*) through supporting the re-introduction of laid-off workers into the labour market; and
c) Mitigate the potential loss of jobs in the advertising sector due to the *step-by-step restriction of advertising and marketing*.

Overall, the political feasibility of the overarching policy mix may suffer from issues of public acceptance, which in turn often relate to concerns of competitiveness, employment and distributional effects, as well as legal feasibility. We will turn to these issues next.

Public acceptability

Public acceptability differs across the instruments contained in the policy mix, with more instruments evoking resistance than receiving support.[33] Low public acceptability is likely for:

- *The Circular economy tax trio* – If material, waste incineration and landfilling are perceived by affected sectors to threaten competitiveness, arguments about concerns of economic leakage and job losses may easily transmit to the public attitude and cause resistance to this instrument. As no border tax adjustment arrangements are foreseen in the instrument description the affected sectors can be expected to seek to make this case.
- *Labour market reform fostering a shift from consumption to leisure* – Similar arguments to those given under socio-economic impacts will also likely cause great resistance to mandatory measures. Learning from discourses surrounding the introduction, implementation and impact of the EU's Working Time Directive (WTD) in the early 1990s, employer associations were found up against the WTD arguing about the negative impacts of inflexibility and increased labour costs and the importance of maintaining employer and job market flexibility for economic competitiveness.
- *Step-by-step restriction of advertising and marketing* – Public support can be found for the early measures, which are in-line with the existing regulatory regime, in particular as regards limiting advertising targeted at children and unfair marketing. The more far reaching restrictions on advertisement of luxury goods linked to conspicuous consumption would, however, raise significant resistance in public opinion.
- *Support for local currencies* – While there is no significant public acceptability issue associated, objections could be expected in cases where the local currencies are primarily motivated by avoiding taxation for those joining the local currency exchange or where use of the local currency becomes compulsory for buyers or sellers.

In contrast, some level of public support could be expected for:

+ *EU-wide introduction of feebate schemes* – This form of environmental tax reform is widely understood and acceptable by the public. However, as regards potential socio-economic impacts the actual selection of products to receive the fee should ensure that the scheme does not discriminate against poorer households, which might not be able to afford more costly items benefiting from the VAT reductions (e.g. an A+++ rated washing machine) in the first place. When feebates are introduced for mostly homogenous products, low-income households will most likely carry the burden of the price increase as investment costs are linked to efficiency. If due to the feebate a needed product category (e.g. a larger car for a larger family) became on average more expensive, discrimination would result and call for accompanying measures mitigating such effects for those in need.
+ *Reduced VAT rates* – Broadly acceptable to most actors, but a main block may come from the EU VAT Directive (2006/112/EC), if minimum requirements (standard tax rate no less than 15% and reduced tax rate no less than 5%) are not complied with. As the instrument description sets the reduced rate at 6%, legal compliance seems to be given.

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[33] The findings presented in this section are based on Vanner et al. (2015).

- *Skill enhancement programmes* – Likely widely acceptable because of the potential mitigating effects of skill enhancement programmes on (i) improving match-making between businesses' skill needs and employees' skills and (ii) alleviating employment and distributional effects of other instruments in the overarching policy mix.

Legal feasibility

As regards legal feasibility no major issues or conflicts with World Trade Organisation (WTO) law or the EU Treaty emerged. For some instruments, relevant aspects to consider are:

e) Under GATS (General Agreement on Trade in Services) and GATT (General Agreement on Tariffs and Trade) restrictions of advertising and marketing can be qualified as measures having equivalent effect to quantitative restrictions on imports. These would be forbidden if these restrictions affect the opportunities for importation itself. There is no guidance available for whether the design of the instrument *Step-by-step restriction of advertisement and marketing* would affect the opportunities for importation. However, the case of tobacco advertising restrictions could be used for orientation. Such restrictions have been adopted for public health purposes by Members without a violation of specific commitments for trade in advertising services. Hence, legal feasibility issues are rather unlikely for *Step-by-step restriction of advertisement and marketing* in this policy mix.

f) When *boosting EPR schemes*, it has to be ensured that product waste streams are not singled out for discriminatory treatment based on their source of origin.

g) *Skill enhancement programmes* may be prone to risks of discriminatory treatment. They hence need to ensure that there are no artificial barriers to entry for students and/or professionals coming from other Member States. (Lucha and Roberts 2015)

At EU level, any harmonisation of legislation concerning turnover taxes, excise duties and other forms of indirect taxation – the three MBIs of the overarching policy mix *Circular Economy Tax Trio*; *EU-wide introduction of feebate schemes*; *VAT reductions* – would require unanimous vote by the Council. A justification would require the action to be "necessary to ensure the establishment and the functioning of the internal market and to avoid distortion of competition" (Article 113 of the Treaty on the Functioning of the European Union, TFEU). Hence, while legally feasible, **political feasibility** seems rather low as the justification according to Article 113 TFEU cannot easily or credibly be established for the three MBIs. This casts doubt on the likelihood of getting unanimity on these suggested instruments.

4 Lessons learnt – policy mix concept and ex-ante assessment of policy mixes

4.1 Policy mix concept

Applying and adapting the heuristic framework for policy mix design proved very interesting in the context of the DYNAMIX project. It allowed us to use different methods for identifying relevant drivers (literature review, the Sensitivity Model[34], and workshops) and helped guide both discussion on as well as the actual selection of potentially promising policy instruments aimed to achieve a wider set of environmental key targets. The discussion around which primary and supportive instruments to select because of which supposed interlinkages and synergetic effects was instrumental in shaping the understanding of the metals policy mix to be more than the sum of its instruments.

In the light of the metals and materials policy mix, applying the concept and the conceptual design of policy mixing has proven useful because it:

- Required a deeper and as much as possible systemic understanding of a given problem situation, its system boundaries and key drivers
- Demanded clarifying objectives and concrete targets that policy shall achieve in relation to the problem situation
- Asked for creating an overview (inventory) of policy instruments promising to help achieving the targets, but during the instrument selection urges to consider positive and negative interactions between the instruments to chose a consistent set-up
- Necessitated to consider political processes that are supportive to or impeding the design and implementation of the policy mix

Our findings point to the usefulness of comprehensive ex-ante assessments for designing promising and theoretically robust policy mixes. However, as the policy mix could be a combination of any instrument(s) that will support achieving the set policy objectives, the crucial design component is to select and combine those instruments which have the potential for maximising synergetic effects and for mitigating negative side effects of the use of other instruments (see Minogue 2002). While such design will benefit from scientific ex-ante assessments, it is complicated by two aspects:

1. the inherent difficulty of assessing cumulative effectiveness of the mix vs. that of the individual instruments given potential synergetic and/or mitigating effects

2. the logical gap between a scientific ex-ante assessment of a policy mix' potential effects on the one hand and the actual implementation of the policy mix in the real-world of politics, multiple interests and polycentric actor constellations, which will inevitably change the nature or design and hence the impacts of the mix through the political processes

Any policy mixing effort will have to undergo several adaptations along the life cycle of the policy mix, which may change it fundamentally from what is was based on an(y) initial scientific ex-ante assessment. The revision of the policy mix will have to continue during and based on the implementation (hence requiring to draw further arrows from Stage (6) in the heuristic framework, Figure 1, to Stages (1), (2) and (3)). This makes policy making a cyclical, iterative and thus inherently long-term approach.

Still both the policy mix concept and the heuristic framework applied offer promising routes to foster policy making in resource policy (and environmental policy in the wider sense). It puts a certain pressure on policy making actors to go beyond so-called policy layering, where new

[34] See here Ekvall et al. (submitted)

instruments are stacked on-top of existing instruments without consideration of potential instrument interactions and long-term strategies (Howlett and Rayner 2007).

The examples given in the introduction on the Icelandic fisheries and the UK aggregates policy mix may serve as a case in point for going beyond policy layering: in both cases the real-world policy mix has received additions over time, where based on initial environmental effects leveling off either new instruments were introduced (individual tradable quotas, ITQs, in the early 1990ies, and expanded to all commercial fishing vessels in 2004 in Iceland (Arnason 2008)) or existing instruments revised (landfill and aggregates tax levels were raised at several times (e.g. 1997 and 1999 for the landfill tax; 2008 and 2009 for the aggregates levy) in the UK (Söderholm 2011).

Furthermore, both policy mixes contributed positive or compensated negative side-effects through (a) making property rights much more efficient through the ITQs, which incentivized modernisatoin and rationalisaton of the Icelandic fishing fleet, improved match-making between supply and demand and created marketable assets – all of which contributed to increasing Iceland's GDP growth rates between 1990 and 2006 (Arnason 2008). And (b) in the case of the UK aggregates tax, economic impacts on affected industries were minimised by (i) exempting aggregates export from taxation and (ii) earmarking tax revenues to reduce employers' national insurance contributions by 0.1% and through the so-called Aggregates Levy Sustainability Fund (ALSF), which supports environmental management at aggregate sites and promotes greater use of recycled aggregates, thus transferring the revenues back to the affected industries (Söderholm 2011).

Overall, the DYNAMIX approach for policy mixing advocates a more long-term ex-ante assessment focus that could enable to maximize upfront policy mix consistency. Development of consistent and coherent policy mixes can contribute to a more effective strategy for policy-making. Nonetheless, neither the DYNAMIX approach nor any other ex-ante assessment for that sake can navigate the political processes, which may impact both on the eventual policy mix design and on the implementation – and hence on the overall effectiveness of the mix. The concept of policy mixes appears to clash with current political realities and practical experience. Further research from organizational theory and political economy is required to investigate under what circumstances such strategic policy-making would be possible and through which actions its feasibility could be strengthened. Such research could maybe build on action research in practice settings.

Designing politically feasible and yet ambitious policy mixes that have the potential to reconfigure systems remains a formidable challenge. This challenge relates both to their conceptualization and assessment of cumulative effects as well as to reconciling long-term forward-looking policy strategies with political economies of election cycles and diverging interests in dynamic multi-actor settings. We suggest taking on this challenge with further scientific rigor, political creativity and innovative coalitions because combining primary and supportive instruments into coherent and time-dynamic policy mixes appears a promising and enabling step on the way to fostering transition and reconfiguration of systems towards sustainability (Geels et al. 2015).

4.2 Ex-ante assessments and uncertainty

The ex-ante assessments undertaken in the context of the DYNAMIX project could only partly be based on harmonised assumptions and parameters. Therefore, the results of the qualitative and the quantitative assessments differ – in some cases significantly. It cannot be stressed enough that the assumptions going in the assessments define the outcome to a great degree.

Furthermore, the simulation models used function in a certain systemic logic, which limits their ability to model some instruments or instrument designs that could lead to systemic changes.

And finally, the assessments undertaken were not able to assess actual cumulative effects of the instrument combination in the policy mix beyond individual effects. This remains a methodological challenge requiring more research. Likewise, not all relevant environmental impacts can be calculated by the quantitative models. In particular, effects on biodiversity and on water quality were not included in the quantitative assessments, leaving them underrepresented in comparison to the other key targets.

5 Conclusions

We used a heuristic but systematic framework for designing promising policy mixes supporting absolute decoupling of EU economic growth from resource use and associated environmental impacts in the EU. We found the framework useful for this purpose, and also for presenting, discussing and justifying the policy mixes and its components. Interaction with stakeholders and external researchers is valuable in this systematic procedure. In the DYNAMIX project, such interaction gave important input to and feedback on the policy mix.

To reduce the risk of burden-shifting, a broad systems perspective is needed when designing a policy mix. This contributes to the complexity of the task, where a huge amount of information is potentially relevant to account for. The distinction between primary and supportive policy instruments is useful when designing a policy mix, and also when presenting it. The boundary between primary and supportive instruments is not sharp, however. Primary instruments aim to achieve the objectives of the policy mix, but are also designed to be as little controversial as possible. Supportive instruments aim to reduce barriers and negative side-effects of the primary instruments, but in several cases also contributes to achieving the policy objectives.

The policy mixes include a larger set of supportive instruments to reduce other barriers, as well as negative side-effects on competitiveness, economic growth and employment. This contributed to fairly positive results from the environmental and economic models used for ex-ante assessment of the policy mixes. However, the quantitative assessment results indicate that the policy mixes will not be sufficient to reach the predefined environmental targets of DYNAMIX.

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