POLFREE
Policy Options for a Resource-Efficient Economy

Grant Agreement no. 308371

ENV.2012.6.3-2 - Policy Options for a Resource-Efficient Economy

- Collaborative project -

D4.6 – Conclusions & Policy Insights

WP 4 – Synthesis of Project Results

Due date of deliverable: Month 36 (extension granted)

Submission date: 24 / 03 / 2016

Start date of project: 1st October 2012 Duration: 42 months

Lead beneficiary for this deliverable: UCL

Last editor: Paul Drummond

Contributors: Paul Drummond

This project has received funding from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No 308371.

Dissemination Level		
PU	Public	PU

History table

Version	Date	Released by	Comments
Final version	24th March 2016	UCL	

Table of contents

1. Introduction

The POLFREE (**POL**icy **O**ptions **F**or a **R**esource **E**fficient **E**conomy) project was structured around three core Work Packages (WPs), each with distinct but interlinked objectives:

- **WP1 – Why have resources been used inefficiently?** This WP saw the construction of a theoretical framework to assess how resources are currently used and why, with detailed analysis of the trends and policies at EU and Member State (MS) level, cross-country econometric analysis to derive resource-reduction cost curves, and an analysis of constraints to resource efficiency amongst businesses and individuals.
- **WP2 – New concepts and paradigms for policies for resource efficiency**. This WP explored new concepts and paradigms that may be able to bring about a radical increase in resource efficiency. This included new, resource-efficient business models and ideas for global governance approaches to promote resource efficient economies. This WP also developed a vision for a resource-efficient economy in the EU, and proposed and assessed policy mixes that may be implemented to achieve this vision.
- **WP3 - Scenarios and modelling of policy implementation for resource efficiency**. This WP saw intensive work on creating, modelling and visualising scenarios for the emergence of resource-efficient economies, through linking quantitative economic and ecological models, and simulating the policies and policy mixes derived in the earlier work, supplemented by LCA analysis for selected products and sectors, to ensure that the policies and business models in the scenarios lead to adequate absolute decoupling of economic activity from resource use and environmental degradation. The scenarios and associated policy analysis were interpreted across economic, ecological and social dimensions.

The purpose of this report is to provide a summary of the key conclusions and policy-relevant insights from the work undertaken on POLFREE. Annex I lists each of the deliverables from the project, from which this report draws (as such, Annex I also operates as a bibliography). All deliverables may be found at www.polfree.eu. Each of the following sections presents a headline conclusion from the POLFREE project, with various related ‘sub-conclusions’ highlighted in bold in the text that follows.

2. What are the key characteristics of a resource-efficient European economy in 2050?

In 2011, the European Commission published a 'Roadmap to a Resource-Efficient Europe' by 2050; a key component of the 'Resource-Efficient Europe Flagship Initiative', itself part of the Europe 2020 strategy. The overarching objective of this Roadmap is to lay the foundations to achieve the following:

'By 2050 the EU's economy has grown in a way that respects resource constraints and planetary boundaries, thus contributing to global economic transformation. Our economy is competitive, inclusive and provides a high standard of living with much lower environmental impacts. All resources are sustainably managed, from raw materials to energy, water, air, land and soil. Climate change milestones have been reached, while biodiversity and the ecosystem services it underpins have been protected, valued and substantially restored'

This formed the basis for development of the POLFREE 'Vision' for a resource-efficient economy in Europe. The Vision, presented in Annex II and developed by Jäger (2014), provides key qualitative and quantitative characteristics that such an economy should exhibit in 2050. These characteristics were derived first through the identification of significant 'sustainability visions' that have been developed in recent years[1], and then through their subsequent analysis against a common analytical framework, which focuses on two assessment pillars – 'nature' and 'wellbeing and quality of life'[2]. The Vision was then refined in a consultative process with stakeholders.

A key output of this process was the generation of quantitative headline targets for the environmental characteristics of a resource-efficient European economy in 2050. Eight such targets were developed – two for each of the four key major resource categories (materials, land, water and carbon). These values were first derived through an assessment of the (in)consistencies in broad objectives of the existing 'sustainability visions', their specific targets, the extent to which these targets converge or diverge, and their realism (based on current understanding of the topics at hand). This process was then complemented by stakeholder consultation. These headline targets are presented in Table 1.

Table 1 - POLFREE Headline Targets for a Resource-Efficient Economy in 2050[3]

	2050 Target	Description
Materials	5 tonnes Raw Material Consumption (RMC) per capita (global)	Returning to a global level of global raw material extraction equivalent to the year 2000 and distributing this level equally among the expected world population in 2050
	No net additions to building	European demand for primary

[1] These studies were selected on based on geographical (including European Union), temporal (2050 and beyond) and thematic (covers natural resource including materials (metals, minerals, fossil fuels, biomass), water, land or carbon). See Jäger (2014, p.8) for a list of the 'sustainability visions' identified.

[2] See Jäger (2014, Annex III) for a full description of this analytical framework.

[3] Adapted from Jäger (2014, p.22)

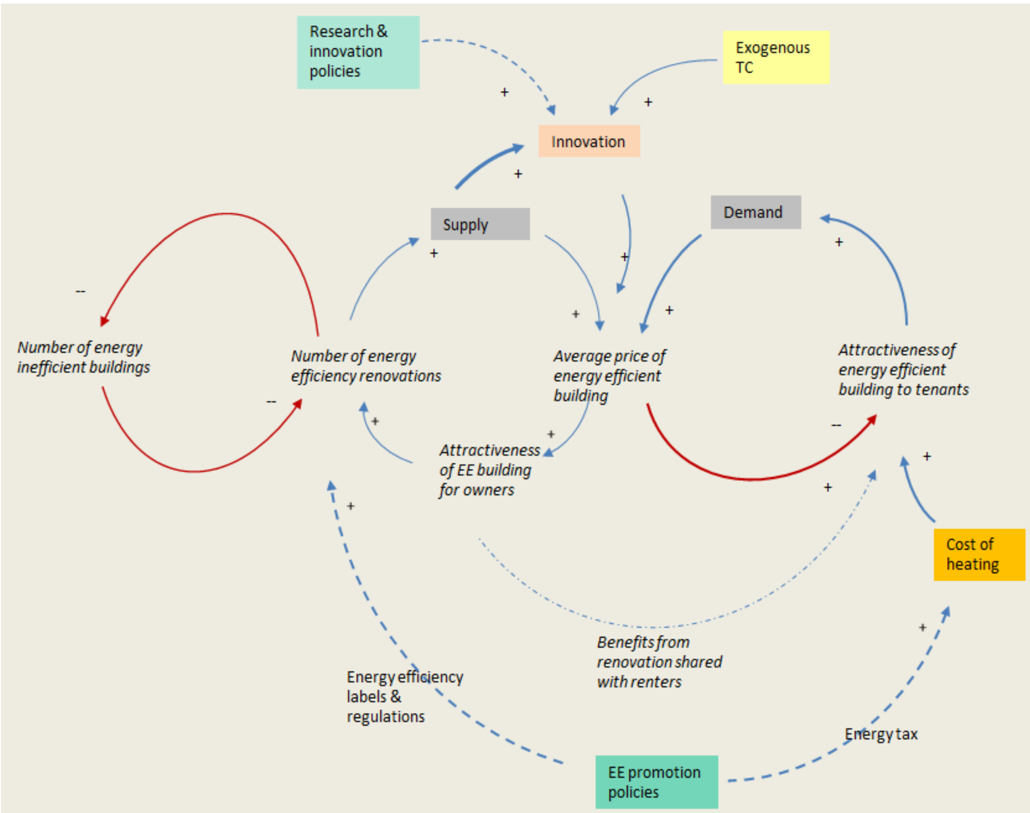
	stock (EU)	resources is reduced to the point that they can be nearly all sourced within the built environment through e.g. urban mining. This also implies a reduced land take and much higher levels of renovation of the existing building stock.
Land	EU global cropland footprint reduced to 0.17-0.20 ha/capita	Low target: planetary boundary for land use change to limit effects of climate change. High target: halt the loss of biodiversity and keep land use change within the safe operating space
	No net loss of cropland (EU)	No net land take due to expansion of built-up land and no soil degradation (implies long-term maintenance of soil fertility through good agricultural practices to ensure production over the years to come). Overarching rationale is to prevent the loss of fertile cropland in the EU.
Water	EU mean global water footprint per capita reduced 30-50% below 2004 levels	The water footprint covers not only the demand consumption of water directly but also the water in imported goods.
	Water Exploitation Index (WEI) below 20% in all EU countries	At 20% a region is defined as being under “water stress”.
Carbon	EU mean global carbon footprint per capita reduced 60-80% below 2004 levels	Considers the impacts of goods and services imported into the EU
	EU GHG emissions reduced by 80-95% (below 1990 levels)	To keep climate change below 2°C from pre-industrial levels

3. There exists a 'web of constraints' to the efficient use of resources

It is clear that across the economy, individually and as a collective, do not use resources as efficiently as we might. A first step in developing a resource-efficient economy, as defined in Section 2, is to determine why this is the case. It is common in this respect to consider resource-inefficiency, and other 'non-optimal' behaviour and outcomes, to be the result of individual 'barriers' or 'market failures'. Examples include market externalities (such as CO_2 emissions or other pollution), split incentives (such as the 'landlord-tenant dilemma', in which the landlord is not incentivised to invest in energy efficiency measures as it is the tenants that would receive the benefit), and information failures.

However, Kemp & Dijk (2013) conclude that resource-efficient behaviour, or the absence of it, depends on many factors in simultaneous operation and dynamic interaction. As such, **the concept of individual, independent 'barriers' to resource efficiency is not sufficient. Instead, a concept of a 'web of constraints' is more appropriate**. An example of such dynamic factors that comprise a web of constraints acting against resource-efficient heating behaviour in residential properties is illustrated in Figure 1.

Figure 1 - Dynamic Factors influencing Resource-Efficient Behaviour surrounding Residential Heating (Source: Kemp *et al*, 2014)



The web of constraints refers to the relationship and dynamic interaction between individual, organisational and institutional behaviour patterns, inertia and direct and indirect interconnections between the institutional, social and individual levels (Kemp *et al*, 2014). For the purposes of assessing the nature of the existing web of constraints to resource efficiency in the EU, the POLFREE project categorised its components as constraints acting within and emanating from the policy and legislative framework (at the EU level and Member State level), within and acting upon business, and those action upon and emanating from individuals as citizens and consumers.

3.1. Policy and Legislative Framework Constraints

3.1.1. European Union

The EU has one of the most advanced policy frameworks in the world for environmental protection, which has steadily grown in both coverage and ambition over time. Resource efficiency has received increasing attention in the environmental policy agenda in recent years, driven significantly by price volatility in commodity markets and its potential impact on supply chains and industrial competitiveness (Domenech *et al*, 2014). The 'Europe 2020 strategy for smart, sustainable and inclusive growth', with its resource efficiency flagship initiative, currently provides the strategic framework for resource efficiency policy development. However, **it is clear that the existing policy landscape is insufficient for producing a trajectory for achieving a resource-efficient economy** as defined in Section 2.

However, it is clear that **the primary focus for environmental policy has been on energy and climate change, with other issues of resource efficiency such as materials, waste and land, largely overlooked** in the European policy landscape. In addition, there is a clear focus on the 'output' side of the use of resource in the economy (e.g. the generation of waste and pollutants), on which binding targets may be found (e.g. GHG targets), with the 'input' side either largely overlooked or addressed through aspirational, non-binding objectives and targets. Indeed, **the absence of a more comprehensive set of indicators and associated targets on resource (including materials) efficiency, or resource productivity (GDP/RMC), is a key gap in the current EU strategy on resource efficiency**. The European Resource Efficiency Platform proposed in 2014 to introduce such a target (set at a 30% increase in resource productivity by 2030 – a value double that of the existing trend) (Domenech *et al*, 2014). However, there is evidence to suggest increasing resistance from some Member States to accept quantitative, binding targets (opposition to additional targets for waste prevention, landfill and recycling exemplifies this). Resistance has also been observed in areas such as soil protection, water and air quality (Domenech *et al*, 2014). In addition, the resource-efficiency agenda appears to have fallen into the 'joint-decision' trap, which favours the status quo and incremental policy shifts, rather than more radical, innovative policy approaches (Kemp *et al*, 2014).

The first Circular Economy Package, issued in July 2014, did relatively little to alter this picture. It sought to increase existing targets for the recycling of municipal waste and packaging through binding targets, and ban all separated waste from landfill by 2025. Most other provisions and targets were aspirational, however this did include an EU wide target of a 30% increase in resource productivity by 2030, as discussed above. The Package was withdrawn in December 2014, after which it was announced it would be re-introduced with 'more ambitious' aims. The reintroduced Package, issued in December 2015, actually reduced the proposed binding targets for recycling, and removed the 2030 resource productivity target. However, it introduced a binding target of limiting landfilling to 10% of all waste by 2030, which was previously a 25% 'aspirational' target by 2025. Additionally, it proposed future changes to elements relating to the upper tiers of the Waste Hierarchy, such as a revision of the Ecodesign Directive to improve the ability for product re-use and recycling. However, the majority of such elements are aspirational, and do little to alter the focus on the lower tiers of the Hierarchy.

In line with the concept of the dynamic web of constraints concept described above, **different EU policy instruments and their component objectives, targets and operating mechanisms experience multiple interactions – of both a synergistic and conflicting nature**. Figure 2, produced by Domenech *et al* (2014), illustrates such mutually re-enforcing relationships (green) and those in conflict (red) between different policy objectives.

Figure 2 - Synergies and Conflicts in the EU Policy Landscape regarding Resource Efficiency (Source: Domenech *et al*, 2014)

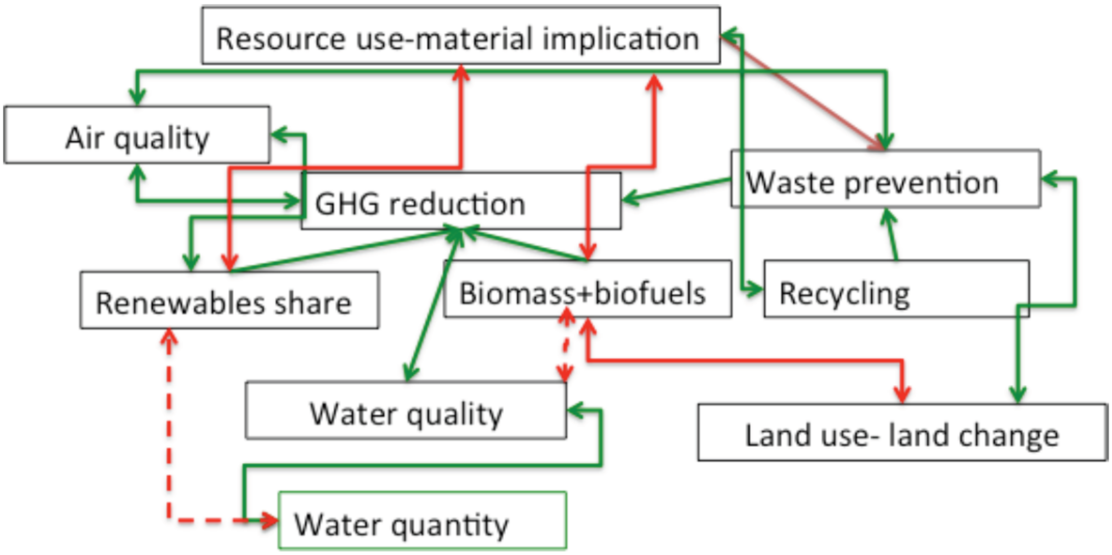


Figure 2 illustrates that the recycling of waste, for instance, could in principle also reduce the consumption of primary raw materials and associated CO_2 emissions (although to date no evidence has been found that increased levels of material recycling and resource productivity in the EU have led to decreased demand on primary materials). However, examples of conflicting relationships are more prominent. A key element of EU Transport policy is to encourage the free movement of people and goods, as part of the single market. However, transport is also a significant source of air pollution, land use and fragmentation, and material use. While the link between transport and air pollution has been the primary focus of sustainable transport policies at the EU level, little attention has been paid to material and land use implications (Domenech *et al*, 2015).

Inconsistency may occur laterally, such as the examples given above, but also over time. Am example is EU waste policy. After years of encouraging investment in high-cost incineration infrastructure, the EU shifted focus to emphasise the role of recycling and a limit on incineration of non-recyclable materials. Whilst justified from a resource efficiency perspective, this implies a double investment in waste management infrastructure and competition for waste streams, increasing costs substantially and potentially producing stranded assets (Domenech *et al*, 2015).

3.1.2. Member States

There is substantial variation across Member States in terms of resource productivity, and in trends over time. Whilst some countries experienced reducing resource productivity, **several countries indicate relative and even absolute decoupling between Domestic Material Consumption (DMC) and GDP growth**. Whilst this variation is likely in part to be driven by the varied institutions, policy instruments and frameworks in place across Member States, it must be noted that a substantial factor is likely the growth in outsourcing of primary material extraction (Kemp *et al*, 2014), rather than a reduction in Total Material Requirement (TMR). Bahn-Walkowiak *et al* (2014) concluded that correlating resource efficiency policy with resource use outcomes is a highly complex exercise, as **the dynamic interaction between factors in the 'web of constraints' makes it difficult to isolate individual 'success factors'** (Domenech *et al*, 2015).

However, Bahn-Walkowiak *et al* (2014) highlight some key weaknesses in the policy framework that may be found in many Member States. A key example is the level of environmental taxation. The weighted average of **revenue from environmental taxes in the EU is marginal compared to other types of taxes** (such as those on labour), and in 2008 represented just 2.4% of GDP. In addition, the majority of such taxes are energy and transport, with pollution and resource taxation representing just 5% of the total. A key factor in this may be political resistance to such taxation. However, this circumstance is made more serious given the **common presence of direct and indirect subsidies to resource-intensive sectors and activities**. Various other **common weaknesses may be highlighted, such as policy inaction, the use of qualitative rather than quantitative targets, insufficient policy coherence (including a lack of clarity regarding the division of institutional responsibility), information deficits and the strong influence of vested interests**.

Another issue is a **common inconsistency between policy principles and objectives, and the instruments introduced**. A key example, linked to that at the EU level, may be found in the waste sector. Whilst application of the waste hierarchy in policy making should lead to the optimisation of resource use, the focus of policy has been largely on landfill diversion rather than the reduction of waste generation in the first place. As discussed above, under both iterations of the Circular Economy Package proposal, this generally remains the case.

3.2. Business-related Constraints

There are three types of Resource Efficiency Measures (REMs) that a business enterprise may undertake (Diaz Lopez *et al*, 2014):

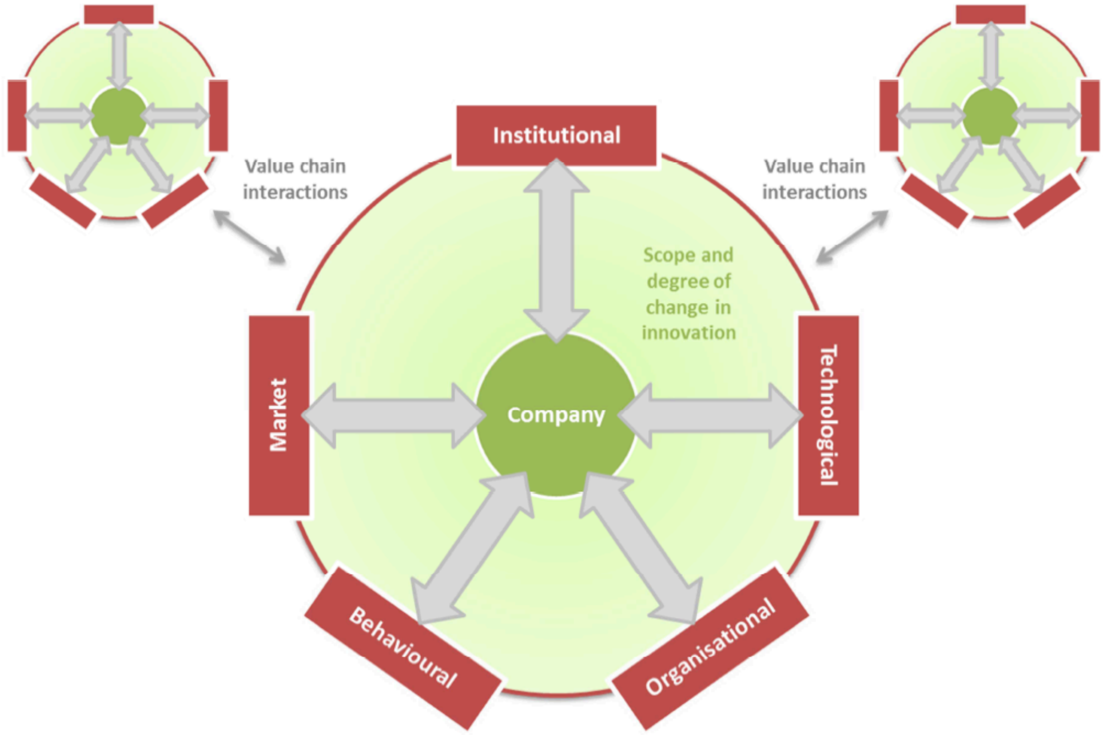
- **Product-oriented measures** – Improving the resource-efficiency products or services provided by the business, through redesign of the product or service, or substitution for a more resource-efficient alternative.
- **Operational-oriented measures** – Improving the resource-efficiency of the internal operations of the business and its supply chain, through, for example, cleaner production, green supply chain management and energy efficiency measures.

- **Lifecycle measures** – Improving the resource-efficiency of the product or service provided across its entire lifecycle, such as through industrial symbiosis, cradle-to-cradle design and the ability to remanufacture.

Diaz Lopez *et al* (2014) assessed the potential for different examples of such measures, and determined that three measures in particular – **green (business) services, cradle-to-cradle design and industrial symbiosis** – hold particular promise. **Such measures not only hold substantial potential for resource-efficiency gains, but also boost business competitiveness** (often across the value chain) (Kemp *et al*, 2014).

However, Bastein *et al* (2014) identify **five key (interlinked) categories of constrains** that businesses may experience that act to prevent the widespread adoption of these and other REMs, as illustrated in Figure 3.

Figure 3 - Five Categories of Constraints to Resource-Efficiency Measures in Business (Source: Bastein *et al*, 2014)

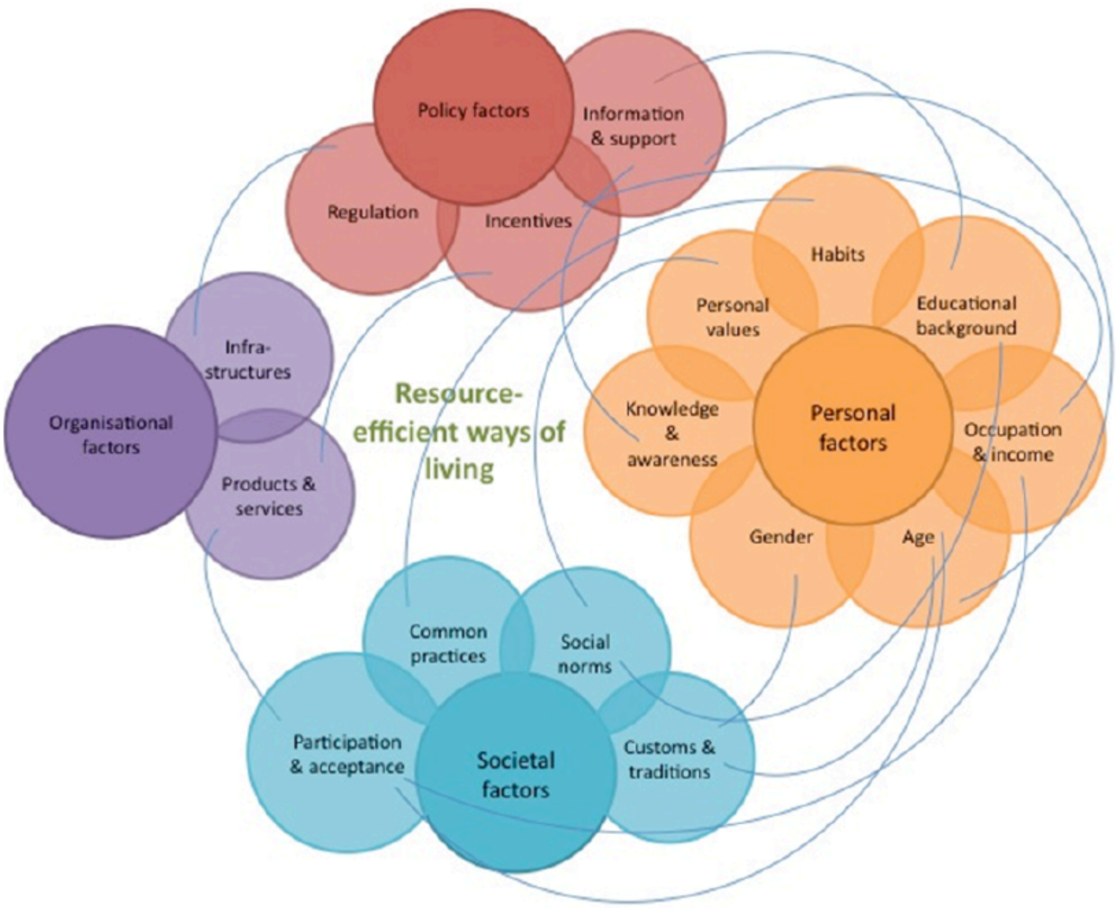


Institutional constraints are those set by political and governing institutions, including the policy landscape (discussed above), the process by which policy is made, and the level to which they are enforced. Linked to this are **market constraints**, which include market failures (such as the market externality of pollution), barriers to market entry, monopolistic structures, environmentally harmful subsidies, information deficits and split incentives. This also relates significantly to constraints associated with the role of individuals as citizens/consumers, discussed below. **Organisational constraints** are those present within a business itself. Examples include supply chain issues, insufficient labour force capabilities, lack of available funds, firm culture and a lack on information. In turn, this links to **behavioural constraints** exhibited by individuals within the firm, including management and employee attitude to innovation and change, and attitudes and social values. The final category, **technological constraints**, includes the availability of technology, its cost, its compatibility with the firm and its operations, and with other categories of constraints outlined above (Bastein *et al*, 2014).

3.3. Constraints with Individuals as Citizens/Consumers

Kammerlander (2014) conduced a survey of households, held focus groups and conducted in-depth qualitative interviews across three EU Member States (Austria, Hungary and the Netherlands), in order to assess drivers and constraints to resource efficiency amongst individuals as citizens and consumers. A key conclusion of this investigation was that **the public are interested in adopting resource-efficient behaviour, but mostly for non-environmental reasons**. For example, whilst around half of the population surveyed indicated a willingness to reduce personal car use, the principal reasons behind this were to save money and to get more exercise. Additionally, whilst between two-thirds and half of respondents in the different countries examined expressed a desire to eat less meat and fish, the primary drivers for this were concerns over personal health and animal welfare. However, regardless of the motivation, such desire is generally not converted into action. As with business-related constraints, the web of constraints acting on individuals as citizens and consumers to prevent this may be broadly grouped into interlinked categories, as illustrated by Figure 4.

Figure 4 - The Web of Constraints to Resource-Efficient Lifestyles (Source: Kammerlander *et al*, 2014)



Personal factors (including individual characteristics, preferences, attitudes, experiences motivation, knowledge, awareness, location of employment and residence, etc.), **societal factors** (including culture, social norms and traditions, etc.), **policy factors** (including policy and legislative framework constraints, discussed above), **and organisational factors** (including the availability of resource-efficient products and services, advertisement and promotion of different products, etc., heavily linked with business related-constraints discussed above), **all interact to produce a web of constraints to resource efficiency amongst individuals**.

T**he presence of and interaction between these factors leads to an apparent inconsistency in resource-efficiency behaviour between individuals and between countries.** For example, Kammerlander (2014) finds that practicing recycling is not correlated with reduce personal car use. This may be, for example, due to the lack of poor quality public transport as an alternative (a commonly cited constraint), preventing resource-efficient behaviour (i.e. an 'organisational' factor – lack of availability of infrastructure or appropriate products and services).

4. The 'web of constraints' may become a 'web of drivers' for resource efficiency, with the appropriate interventions

Tukker *et al* (2013) undertook an assessment of thirty of the most prominent concepts and paradigms often touted as potentially substantial contributors to improving resource efficiency and promoting an environmentally sustainable economy. Each concept was assessed in order to examine it's potential for contributing to such an objective, using three criteria:

- **Scope of change**. At what scale does the concept focus? Does it focus on improving resource efficiency in a specific sector, a wider value chain, or does it seek to alter the operation of a societal (sub)-system?
- **Paradigmatic degree of change**. How far does the concept seek to alter activities within the existing utilitarian, neo-classical paradigm, or how far does it seek to change this overarching paradigm? For example, does the concept focus on market-based solutions, does it encourage recognition of the public good character of resource-related issues (and this the need for government intervention), or does it seek to induce fundamental paradigm shifts in the economic system, in values, or in institutions?
- **Clarity of change**. Does the concept provide a clear and explicit pathway or formula for how it may be implemented, and what implementation may mean? Or is it unclear in such respects, and only provide a vague or conceptual definition?

Each concept was awarded a 'high' (1), 'medium' (0) or 'low' (-1) score for each criterion. A summary of the analysis is illustrated in Table 2. For more information, including definitions of each of the concepts, please refer to Tukker *et al* (2013).

Table 2 - Resource Efficiency Concept Assessment (Source: Tuckker *et al*, 2013)

No	Concept	Scope of change	Paradigmatic degree of change	Clarity of change
1	Industrial Ecology	1	-1	0
2	Industrial Symbiosis	0	-1	0
3	Waste Prevention	0	0	1
4	Extended Producer Responsibility	0	-1	1
5	Supply Chain Management	0	-1	1
6	Leasing Society	1	1	-1
7	Ecological Economics	1	1	0
8	Natural Step	1	1	0
9	Weak Sustainability	1	-1	1
10	Strong Sustainability	1	0	1
11	Small is Beautiful	1	1	0
12	Eco-Innovation	1	0	1
13	Transition Management	1	0	0
14	Green Growth	1	-1	1
15	Green Economy	1	0	1
16	Beyond GDP	1	-1	0
17	Cleaner Production	0	-1	0
18	Eco-efficiency	0	-1	1
19	Resource Efficiency	0	0	0

20	Pollution Prevention Pays	0	-1	1
21	Sustainable Consumption and Production	1	0	0
22	Product-Service Systems	1	1	0
23	Circular Economy	1	-1	0
24	Reduce, Re-use, Recycle	1	-1	0
25	De-growth	1	1	0
26	Resilience & Safe Operating Space	1	1	0
27	Hannover Principles	-1	1	-1
28	Base of Economic Pyramid	0	-1	0
29	Leapfrogging	0	0	0
30	Slow Food & Transition Towns	1	1	0

From this analysis, Tukker *et al* (2013) drew two key conclusions. The first is that **concepts that provide a vision of deep and far-reaching change, usually fail to provide a clear and credible pathway for implementation**. The second is that **concepts that have a clear and credible pathway for implementation would likely result in incremental, minor change rather than radial shifts towards resource efficiency.** The reasoning behind these conclusions is relatively intuitive. Radical, paradigmatic change implies a shift away from existing practices, infrastructure and in some cases power structures, such that securing the societal and political will to implement them is, in the short-term at least, extremely difficult. Such a situation is emblematic of the web of constraints.

Due to the complex, dynamic interactions between the different components of the web of constraints, an alteration to one aspect may induce changes (either positive or negative) in other areas. As such, **strategic policy interventions may transform the web of constraints to resource efficiency, into a 'web of drivers' for resource efficiency**. Over time, windows of opportunity for the development and implementation of radical technologies and practices, or the policy instruments to drive or facilitate them, that were previously untenable, may be opened (Kemp & Dijk, 2013). Due to the mutli-aspect nature of resource-inefficiency and its consequences, and the web of constraints to its correction, a 'first-best optimum' approach of applying a single policy instrument to counter the problem is insufficient. **A policy instrument mix**, instrument applying 'second-best' theory and the Tinbergen Rule, **must be employed** (Wilts *et al*, 2014a).

Wilts *et al* (2014a) identified nine policy 'fields' from which instruments in the policy mix may be drawn[4]. Under each policy field, three instruments were selected for further analysis, representing instruments aiming to achieve 'low-hanging fruits' in resource efficiency, more direct market interventions, and those that aim at inducing a systematic transformation of production and consumption patterns. Each instrument in each policy field was assessed against the following six design criteria:

- **Stringency** – The ambition of the instrument, relative to existing characteristics of targeted actors and contextual (e.g. market) factors.
- **Profitability** – Whether or not implementation of the instrument would likely lead to a financial return to targeted actors.

[4] 'Phasing out Environmentally Harmful Subsidies', Internalisation of External Costs', 'Resource-Efficient Mobility', 'Resource-Efficiency in the Building Sector', 'Minimisation of Food Losses and Waste', 'Resource Efficiency by Product Service Systems', 'From Waste Disposal towards a Resource-Efficient Circular Economy', and 'Resource Efficiency by Industrial Symbiosis'.

- **Predictability** – The certainty and foreseeability of the detail of the instrument (now and in the future), and subsequent impacts.
- **Flexibility** – How prescriptive the instrument is in how targeted actors must meet its requirements, and the options available to do so.
- **Differentiation** – The level to which the instrument places differentiated requirements or other properties on actors with different characteristics or contextual conditions.
- **Depth** – The extent to which the instrument provides an incentive to continually improve or stimulate investment in resource efficient technologies and practices.

Each instrument was assigned a score of 1 to 5 against each of these criteria, with 1 indicating a low score (e.g. low stringency, poor profitability, etc.), 5 indicating a high score (e.g. ambitious, highly predictable, etc.). From this assessment, Wilts *et al* (2014a) drew three key conclusions. The first is that **the more ambitious (stringent) an instrument is, the lower the immediate profitability to the actors targeted**. There is a clear trade-off between those instruments that offer the highest potential for increasing resource efficiency, and those that are most easily introduced (as discussed above). The second conclusion is that **there is a clear trade-off between the predictability of an instrument, and its flexibility**. This is a relatively intuitive notion. Taking the example of a tax, a clear, long-term rate trajectory comes at the expense of the ability of policy makers to alter it in light of contextual developments (such as technological developments, or evidence of effectiveness). However, there are approaches to deal with this trade-off, such as pre-determined rules for the revision of key design elements (e.g. degression mechanisms for renewable support instruments). The third conclusion is that **there is a trade-off between the level of specificity (differentiation) of an instrument and its depth**. For example, whilst regulatory instruments are more easily able to take into account different characteristics between sectors, firms or regions, they tend not to provide the dynamic incentive to continually improve resource efficiency (beyond the level required by the regulation). The reverse generally holds true for economic instruments, such as taxes.

These conclusions further solidify the need for a policy mix, in order to overcome or reduce the presence of these trade-offs. Wilts *et al* (2014a) also advance criteria for selecting the appropriate instruments for development of an effective resource efficiency policy mix. **The first is consistency**, which may be defined in terms of '**weak consistency**' (the absence of contradictions or conflicts within or between instruments and elements of the policy mix), and '**strong consistency**' (the presence of complementarities, mutual support and synergies between instruments and elements of the policy mix). The **introduction of instruments that enable mutual benefits with existing instruments, and that aim to reduce the presence of negative interactions or side effects**, **should be a priority (**Wilts *et al*, 2014a).

Broadly, any instrument that internalises negative externalities (such as a resource intensity-based tax) or reduces perverse subsidisation (environmentally harmful subsides), acts to improve the overall efficiency of market processes and acts in a mutually supportive manner with other categories of policy instrument (in a well-designed mix). However, there is also a wide range of potential conflicts. An example is instruments intended to directly promote electric vehicles, in order to reduce emissions of greenhouse gasses and local air pollutants. Lettieri *et al* (2015) undertook lifecycle assessments (LCA) of electric (lithium-ion) passenger cars (EVs), and an internal combustion passenger car (diesel and gasoline). They found that whilst the lifecycle of EVs does indeed produce fewer GHG and local air pollutant emissions (although the manufacturing phase is around double the GHG intensity than for internal combustion vehicles, this is offset by the 'use' phase of the vehicles), they require more intensive use of metals, chemicals and energy (again during the manufacturing stage), and produce significantly higher toxicity impacts both in terms of human health and for water contamination. As such, an instrument mix that does not account for such impacts is not producing effects fully consistent with its objective.

The second criterion of an effective resource efficiency policy mix is coherence of the policy processes for development, implementation and monitoring of instruments, within and between different levels of governance. Such a criterion is particularly important in the EU, with competences split between the EU, national and local levels. Indeed, Wilts *et al* (2014a) find that a division in competences in such a way is desirable; whilst some instruments may be most effectively and efficiently applied at the EU level, some instruments are more appropriately introduced at the national or local levels. **A priority for the existing policy mix in the EU should be to improve co-ordination within and between governance levels for existing instruments**.

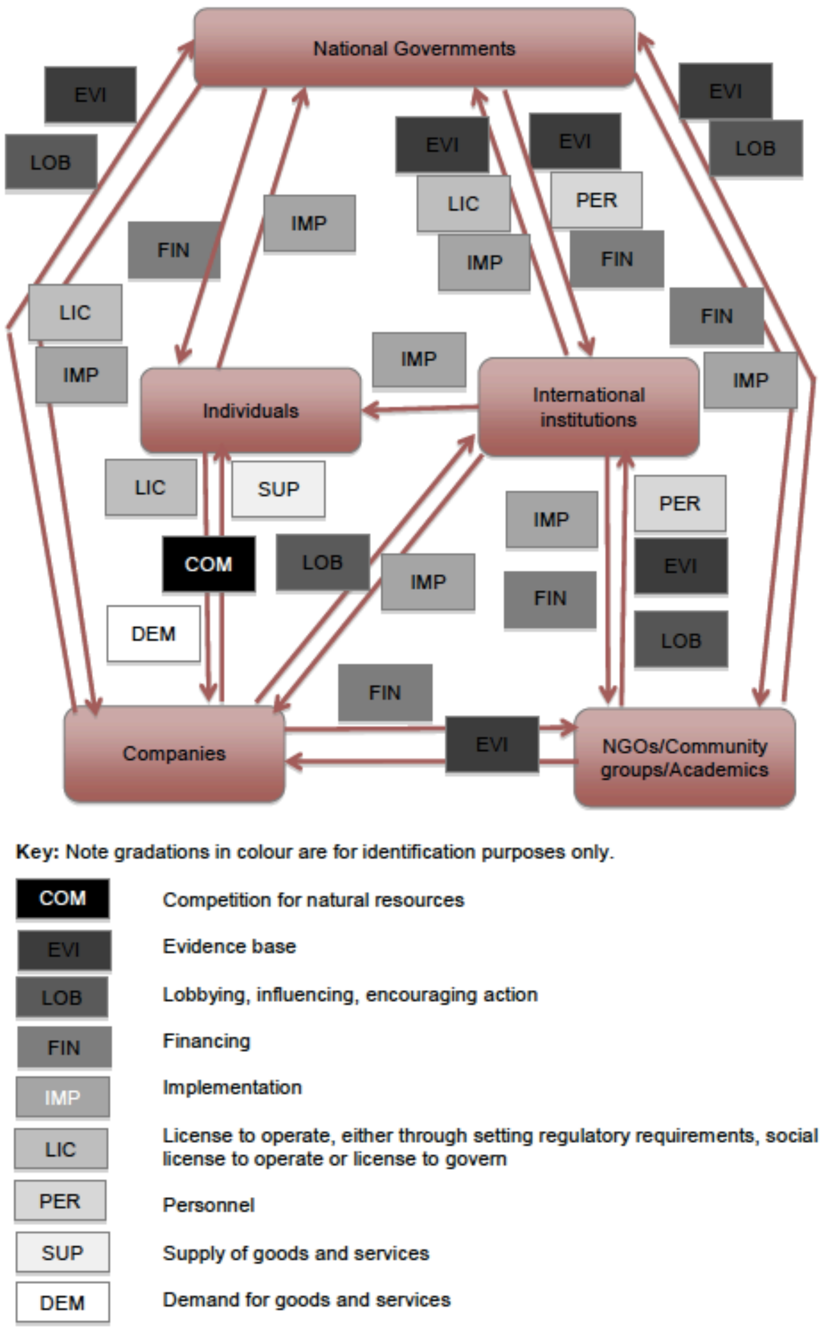
The third and final criterion is credibility and stability from the perspective of targeted entities and other market actors, to provide confidence in the market for long-term investment in resource-efficient technologies and practices. Credibility is influenced by a range of factors, such as political commitment, the operationalisation of targets by the instrument mix, and the delegation of competences to independent agencies (Wilts *et al*, 2014a). Of course, consistency and coherence of the policy mix and related processes are also important factors in whether actors perceive the instrument mix to be credible. Similarly, instrument mix stability is linked to the 'flexibility' and 'predictability' assessment criteria applied to individual instruments, as discussed above. However, 'stability' also concerns overarching strategies, targets and policy processes that transcend individual instruments. Indeed, **the development of long-term core strategies and targets for the development of a resource-efficient economy is a key precondition to its achievement** (Wilts *et al*, 2014b).

5. Policy intervention to achieve a resource-efficient economy by 2050 would be environmentally and economically beneficial

5.1. Governance and Resource-Efficiency Transition Scenarios

O'Keeffe *et al* (2014) sought to map out, describe and analyse the different approaches to governance of resources, the actors involved, and the interactions between them. Figure 5 illustrates the results of this analysis.

Figure 5 - Actors in Resource Governance and their Inter-relationships (Source: O'Keeffe *et al*, 2014)



From Figure 5, two distinct governance[5] approaches and three categories of actors may be distilled. The first approach is **'top-down' governance**, led by two categories of governance actors - **international institutions** and **local, national and supra-national governments**. Top down governance driven by international institutions (such as the Bretton Woods Institutions and UN Institutions and Agencies) occurs through both 'hard law', such as binding multilateral agreements or conventions, coming into effect when ratified by the majority of countries, and 'soft law' such as objective-based, non-binding 'agreements' and co-operative initiatives. Examples of the former with most relevance to resources include the Convention on Biological Diversity, The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, and The Convention on the Protection and Use of Transboundary and International Lakes. Examples of the latter include Agenda 21, the Millennium Declaration and the recently developed Sustainable Development Goals (SDGs). **At present, no specific permanent international organisations exist for the management of resources** (O'Keeffe *et al*, 2014). Top-down governance driven by local, national or supranational governments (such as the EU), includes both the implementation of international governance mechanisms, but also provides the specific policy and regulatory framework actors within those jurisdictions are subject to, and may also introduce 'soft' initiatives.

The second approach is **'bottom-up' governance**, driven by the third category of actors - **civil society** (including individuals, companies, NGOs, community groups and academics). 'Bottom-up' governance mechanisms of particular relevance to resource management include voluntary certification schemes (such as Fair Trade and Marine Stewardship and Forestry Stewardship Certification), Corporate and Social Responsibility (CSR) reporting, and the Model Mining Development Agreement Project. **Such mechanisms are traditionally thought of as local and regional level activities, however increasingly they are having a global reach** (O'Keeffe et al, 2014).

Based on the categorisation of actors developed by O'Keeffe *et al* (2014), Jäger & Schanes (2014) defined three alternative, plausible future socio-economic development pathways to achieve the Vision for a resource-efficient economy in 2050, as described in Section 2, and the associated headline targets presented in Table 1. For each scenario, specific narratives and policy mixes were developed for each of the key resource-intensive sectors (power, industry, buildings, mobility and land use). The policy instruments include combinations and different emphases on economic instruments (e.g. taxes and subsidies), regulation (e.g. standards, binding targets, bans), cooperation instruments (e.g. international agreements), information-based instruments (e.g. certification, labelling and awareness campaigns), Research, Development and Innovation (RD&I) (e.g. research funding), and 'self-committing' elements (e.g. changes in values and behaviour, that may or may not be stimulated through policy initiatives). Each scenario was subject to stakeholder consultation before finalisation. The three scenarios are[6]:

---

[5] O'Keeffe *et* al (2014) employs a broad characterisation of governance, leading from the UN International History Project definition (O'Keeffe *et al*, 2014, pg.14), encompassing traditional state led institutions and actors, as well as those emerging from individuals, community, not for profit and business groups, with the full suite of formal and informal mechanisms.

[6] For more detailed descriptions of the scenarios, refer to Jäger & Schanes (2014, pg.13)

- **Global Cooperation**[7] – Global commitment to resource-efficiency and a sustainable economy is expressed through strong, binding targets and processes set by multilateral agreements, with all countries committed to achieving their aims (with the EU playing a strong global role). The emphasis shifts to 'green growth', with integrated resource markets generating a high level of trade in commodities (supported by agreements on transparency and governance). An Integrated Resource Management Agency (IRMA) is established to support global information gathering and sharing, and to co-ordinate and implement resource-related targets, instruments and processes across different policy fields. Harmonised market-based instruments predominate, with lifestyles and preferences of society driven by extrinsic motivations, and shaped by top-down structures and systems.

- **EU Goes Ahead**[8] - Multilateral agreements and processes are present, but are manifest mainly through issue-focussed 'coalitions of the willing', concerned with information sharing and voluntary measures. Although a global commodity market is in place, availability of resources is commonly disrupted due to instances of 'resource nationalism'. This contributes to the decision by the EU to unilaterally pursue a resource-efficient, environmentally sustainable economy by 2050, through 'green growth'. Top down structures and market-based instruments again dominate (with mechanisms introduced to protect the international competitiveness of Industry in the EU), supported by regulations and standards, with the focus on developing and deploying new resource-efficient, low-carbon technologies, rather than wholesale changes in behaviour.

- **Civil Society Leads**[9] - As with 'EU Goes Ahead', although multilateral agreements and processes are present, they are relatively weak, and disruption to the free trade in resources is relatively common. Although in this scenario the EU again pursues a transition to a resource-efficient, low-carbon economy, this is driven by intrinsic changes in the behaviour and preferences of civil society and non-governmental actors. The role of the EU and Member State governments is not so much to lead the transition, but to create the appropriate conditions for this bottom-up process to develop. Significant changes in the lifestyle of European citizens occurs, including a focus on local, seasonal food, a radical shirt from personal transport to public transport, walking and cycling, and a dramatic decrease in employment in the formal economy in favour of volunteering in the local community, and increased leisure time. Progress is measured using a 'Beyond GDP' approach, which incorporates health, happiness and the 'ecological rucksack' of the individual.

A **Business-as-Usual** scenario was also elaborated, in which increased concern for the environmental sustainability of the economy fails to materialise, either with 'top-down' institutions (international, EU-level, national or local), or 'bottom-up', civil society actors. As such, associated policy measures in the EU or the rest of the world are not introduced, or for those currently in place, ambition is not increased.

[7] Initially called 'Strong Cooperation' in Jäger & Schanes (2014)
[8] Initially called 'Strong Europe' in Jäger & Schanes (2014)
[9] Initially called 'Strong Civil Society' in Jäger & Schanes (2014)

5.2. Modelling Approaches and Modelling Results

In order to assess the implications of the three scenarios for the transition to a resource-efficient economy described in Section 5.1, each scenario was analysed by two economic models of different theoretical backgrounds – GINFORS and EXIOMOD.

GINFORS is a global model, with a deep sectoral and regional structure. It uses a Neo-Keynesian theoretical approach, with assumptions of bounded rationality, agents acting with information deficits on imperfect markets, with imperfect foresight regarding future developments. The integration of a Multi-Regional Input Output (MRIO) model means that GINFORS is able to calculate all direct and indirect emissions and material flows related to the activity of the sectors and countries depicted (Meyer *et al*, 2015).

EXIOMOD (Extended Input-Output MODel) is a Computable General Equilibrium (CGE) model, which uses standard Walrasian closure to guarantee equilibrium between supply and demand. Prices and quantities are perfectly flexible and adjust in each time period to clear all markets. The 'extended' definition refers to the ability of the model to extend the analysis of a standard Input-Output (IO) analysis to environmental impacts (amongst others). EXIOMOD employs the detailed Mutli-regional Environmentally Extended Supply and Use Input-Output database EXIOMOD, which estimates emissions and resource extractions by sector, and trade in different commodities between countries (in both monetary and physical terms) (Hu *et al*, 2015)

In order to allow for a holistic analysis, GINFORS and EXIOMOD were both linked to the Lund-Postdam-Jena dynamic global vegetation model with management land (LPJmL). LPJmL uses process-based representations of major bio-geochemical, bio-geographical and bio-geophysical processes to simulate the role of vegetation and soils in the earth system, particularly with respect to their influence on the global cycles of carbon and water, the effects of human land use on the global environment, and the impacts of climate change on natural ecosystems and agriculture. Such coupling required new features and modules in both GINFORS and EXIOMOD, to maintain consistency in the analysis and to facilitate data exchange. Such technical aspects are detailed in Reynés (2013) Reynés & Hu (2014) for EXIOMOD, and Meyer & Diestelkamp (2013) and Meyer *et al* (2014) for GINFORS.

The first key conclusion resulting from the application of the four scenarios (the three 'transition' and the Business-as-Usual' scenario) to the two model couplings is that **different modelling approaches may produce very different results and conclusions**. Whilst the 'transition' scenarios applied to the GINFORS/LPJmL coupling largely achieve the targets for a resource-efficient economy as presented in Table 1, this is not the case in the EXIOMOD/LPJmL coupling. This may be explained by three key differences between the models and simulations. The first and most important key difference is the modelling principles employed by the two economic models. GINFORS employs a Neo-Keynesian approach using econometrically based parameterisations, whilst EXIOMOD employs a CGE approach using literature-based parameterisations. In EXIOMOD, the assumption of price elasticities of zero for intermediate demand means that taxation of such goods on a resource-intensity basis is not able to change the structure of production directly. This is a key contributor to the inability of the EXIOMOD/LPJmL model coupling to successfully project a resource-efficient future. Additionally, the assumption of a price elasticity of demand of -1 for consumption goods shifts the supply function to the right, and generates a new equilibrium with a lower price and a higher demand and production. This raises the input of resources. This rebound effect is strengthened by a strong reduction in imports, which have a price elasticity of -5. As such, the reduction of the consumer price will strongly reduce imports and increase domestic production further. The second key difference is the different approach to implementing the scenarios and associated policy mixes in the models. The third key difference is the specific implementation of the Reference (Business-as-Usual) scenario, against which the 'transition' scenarios are compared (Diestelkamp *et al*, 2015). For these reasons, the remaining conclusions from the modelling are based on the results of the GINFORS/LPJmL coupling.

Four key conclusions may be taken from the (GINFORS/LPJmL) modelling. The first is that **a Business-as-Usual approach to the relationship between the economy and the environment produces highly negative consequences for both**. By 2050, increasing consumption of fossil fuels driven by economic and population growth leads to global CO_2 emissions more than doubling from 1990 levels, producing an increase in global average surface temperatures of between 4 and 6°C by the end of the century. Other environmental pressures also increase to 2050, such as an increase in global raw material consumption per capita (~40% from present levels), global water abstraction (~35% from 2000) and agricultural land use (~10% from present levels). Such increasing demand induces higher prices for key commodities, such as oil, ores and crops (average increase in real prices by 1.6%, 4% and 2.1% per year, respectively). Average GDP growth rates reduce over time, both globally (from around 2.6% over the last 20 years, to 2.1% from the present day to 2050), and in the EU (from around 1.5% over the last 20 years, to 0.9% from the present day to 2050). Employment reduces by around 30 million by 2050 (a reduction of around 15% from current levels). In this future, the risk of resource nationalism and conflict increases over time, along with social issues resulting from increased prices for essential commodities (e.g. crops) (Meyer *et al*, 2015). Substantial costs from the impact of climate change may also be expected, but are not considered in the simulations.

The second key conclusion from the modelling is that **global cooperation to achieve a resource-efficient economy would be highly favourable against a Business-as-Usual approach**. In the Global Cooperation scenario, global CO_2 emissions peak at around 2020, and decrease to around 11% below 1990 levels by 2050. The policy mix induces strong investments in new resource-efficient technologies, reducing demand for resources, and consequently prices (including food prices), against the Business-as-Usual scenario. All environmental targets listed in Table 1 are achieved. Social tensions arising from increasing food prices in the Business-as-Usual scenario are likely to be less prominent (if not diffused), along with the risk of resource conflicts and damage costs from climate change. Global GDP is consistently higher than in the Business-as-Usual scenario (5.2% by 2050), whilst GDP in the EU is even stronger (8.2% by 2050) - a function of the role of the EU as a consumer rather than producer of resources. Employment is also higher. Only some resource-producing industries, such as mining and quarrying, coke and refined petroleum and food and beverages, experience reduced value-added against a Business-as-Usual trajectory; all other economic sectors are 'winners'. The results of this scenario suggest that **an appropriate policy mix, when well targeted, may**

produce economic as well as environmental benefit, leading to 'decoupling' of economic growth and environmental degradation, both within the EU and globally (Meyer *et al*, 2015).

Indeed, the results of the modelling and the findings of O'Keeffe *et al* (2014) suggest that **resource efficiency and the sustainable use of resources can and should be tackled at the international level**. Given the high and increasingly interconnected nature and interdependency of international trade, and the transboundary impacts of environmental degradation (including climate change), a cooperative global effort would be the approach most likely to guard against the environmental, economic and social consequences a Business-as-Usual scenario is projected to bring. As the world's largest importer, a member of the G8, home to three of the top ten largest stock exchanges in the world (by market capitalisation) and to four of the 10 largest companies globally (based on the Fortune 500), **Europe is a significant player in global governance, and can use its influence in agenda setting at important international fora to ensure that resource use sustainability remains in focus**. **Priorities for action may be to establish a clear and targeted governance structure for resources, perhaps through the establishment of an Integrated Resource Management Agency** (as discussed in Section 5.1). There are also clear opportunities to address some issues of resource use sustainability, such as through extended Sustainable Commodity Agreements (O'Keeffe *et al*, 2014).

However, it must be recognised that there is general scepticism surrounding multilateral approaches to environmental issues. Until recently, this was exemplified by the repeated failure to reach a global consensus on a process to tackle climate change (O'Keeffe *et al*, 2014). **If a globally cooperative approach fails to materialise in the foreseeable future, the EU may reap substantial benefits if it pursues resource efficiency unilaterally**. Under the EU Goes Ahead scenario, the EU is the only region in the world that rigorously improves its resource efficiency and the environmental impact of their use (meeting the targets presented in Table 1). By doing so, it insulates itself from increasing commodity prices (which increase in line with the Business-as-Usual scenario, as the reduction in EU resource consumption is relatively insignificant in the face of continually increasing global demand). It also realises a first-mover advantage through the development and deployment of new resource-efficient technologies and behaviours. As such, GDP in the EU grows at a higher rate than in the Global Cooperation scenario, to 12.4% larger than the Business-as-Usual scenario by 2050, whilst employment is increased by 3.5 million jobs (~2%) by 2050 against the Business-as-Usual scenario (Meyer *et al*, 2015). Distelkamp & Meyer (2014) conclude that even limited increases in efficiency in the use of key resource inputs to industrial processes in the EU would yield a global reduction in resource extractions by up to 2 billion tonnes within five years, accompanied by an increase in EU GDP by 0.1-0.6% per year. However, as the rest of the world continues along a Business-as-Usual pathway, leading to the increasing potential for conflicts and damages from climate change (CO_2 emissions remain on a trajectory for 4°C increase), the implications of which are not examined by the models but which are likely to be costly, a globally cooperative approach should remain the priority.

The modelling also suggests that **a strong post-consumerism movement in European civil society may also drive resource efficiency**, and achieve the targets presented in Table 1. Whilst international developments are similar to those under the EU Goes Ahead scenario, key differences emerge in the EU. Although the impact on employment is positive (9% increase in the number of jobs by 2050 against Business-as-Usual), this is a result of the increase in part-time jobs and reduced working time per capita. This produces lower labour productivities and wages. Annual GDP growth reduces to zero by 2050, with the absolute size of the EU's economy over 21% lower than Business-as-Usual by 2050. However, it is also assumed that this scenario emerges as a 'Beyond GDP' future in the EU, in which measures of progress are diversified beyond growth in GDP.

Although an independent shift in culture towards more resource-efficient practices and preferences may achieve the Vision of a resource-efficient economy described in Section 2, policy makers cannot rely on such a shift coming to pass. However, **the policy framework should facilitate 'bottom-up' actions and processes, in order to maximise their potential** (O'Keeffe *et al*, 2014).

Annex I: List of POLFREE Deliverables

Citation	Deliverable No	Authors	Title
Work Package 1 – Why are resources used inefficiently?			
Kemp & Dijk (2013)	1.1	Kemp, R and Dijk, M	Analytical Framework of Drivers and Barriers to Resource Efficiency
Domenech *et al* (2014)	1.2	Domenech, T., Bleischwitz, R., Ekins, P., O'Keeffe, M., Drummond, P	Lessons from EU Policy Experiences
Bahn-Walkowiak *et al* (2014)	1.3	Bahn-Walkowiak, B., von Gries, N., Wilts, H., Schefer, S.	Comparing Trends and Policies of Key Countries: Report about Drivers for Resource Decoupling and the role of National Policies
Distelkamp & Meyer (2014)	1.4	Distelkamp, M. and Meyer, M.	Report about Resource Reduction Cost Curves for Material Consumption in Different MS and Sectors
Bastein *et al* (2014)	1.5	Bastein, T., Koers, W., Dittrich, K., Becker, J., Diaz Lopez, F.J.	Business Barriers to the Uptake of Resource Efficiency Measures
Kammerlander (2014)	1.6	Kammerlander, M.	Individual Behavioural Barriers to Resource Efficiency
Kemp *et al* (2014)	1.7	Kemp, R., Dijk, M., Domenech, T., Wieser, H., Bahn-Walkowiak, B., Weaver, P.	Synthesis Report and Conclusions about Drivers and Barriers
Work Package 2 – New concepts and paradigms for policies for resource efficiency			
Tukker *et al* (2013)	2.1	Tukker, A., Domenech, T., Ekins, P., Jäger, J., Hartwig, F., Kemp, R.	Report about Synthesis of New Concepts
Jäger (2014)	2.2	Jäger, J.	A Vision for a Resource Efficient Economy
Wilts *et al* (2014a)	2.3	Wilts, H., von Gries, N., Bahn-Walkowiak, B., O'Brien, M., Busemann, J., Domenech, T.,	Policy Mixes for Resource Efficiency

Diaz Lopez *et al* (2014)	2.4	Diaz Lopez, F.J., Becker, J., Berkers, F. Eris, B., Koers, W., van Vliet, H., Bastein, T.	New Business Models that Support Resource Efficiency
O'Keeffe *et al* (2014)	2.5	O'Keeffe, M., Jäger, J., Hartwig, F., Armeni, C., Bleischwitz, R.	Report on Global Governance for Resource-Efficient Economies
Wilts *et al* (2014b)	2.6	Jäger, J., Hartwig, F., Kemp, R., Wilts, H., von Gries, N., Bahn-Walkowiak, B., O'Brien, M., Dijk, M., Diaz Lopez, F.J., Becker, J., Berkers, F., Eris, B., Koers, W., van Vliet, H., Bastein, T., Bleischwitz, T., Domenech, T., Ekins, P., O'Keeffe, M., Armeni, C.	Synthesis and Conclusions
Work Package 3 - Scenarios and modelling of policy implementation for resource efficiency			
Reynés (2013)	3.1	Reynés, F.	Report about the Modelling of Water Demand and Land Use in EXIOMOD
Meyer & Diestelkamp (2013)	3.2	Meyer, B. and Diestelkamp, M.	Report about the Modelling of Water Demand and Land Use in GINFORS
Reynés & Hu (2014)	3.3	Reynés, F. and Hu, J.	Report on the Linking of EXIOMOD and LPJmL
Meyer *et al* (2014)	3.4	Meyer, B., Beringer, T., Diestelkamp, M., Hohmann, F.	Report on the Linking of GINFORS and LPJmL
Jäger & Schanes (2014)	3.5	Jäger, J and Schanes, K.	Report on Scenario Formulation
Lettieri *et al* (2015)	3.6	Lettieri, P., Evangelisti, S., Tagliaferri, C., Domenech, T., Dijk, M.	Report about Modelling Results from LCA Perspective
Meyer *et al* (2015)	3.7a	Meyer, B., Diestelkamp, M., Beringer, T.	Report about Integrated Scenario Interpretation GINFORS/LPJmL Results
Hu *et al* (2015)	3.7b	Hu, J., Moghayer, S., Reynés, F.	Report about Integrated Scenario Interpretation EXIOMOD/LPJmL Results

Diestelkamp *et al* (2015)	3.7c	Diestelkamp, M., Meyer, B., Moghayer, S.M.	Report about Integrated Scenario Interpretation – Comparison of Results
Work Package 4 – Synthesis, Conclusions and Policy Insights			
Domenech *et al* (2015)	4.1	Domenech, T., Kemp, R., Dijk, R., Ekins, P., Bleischwitz, R., O'Keeffe, M., Armeni, C., Drummond, P., Jäger, J., Hartwig, F., Hinterberger, F., Kammerlander, M., Wilts, H., Bahn-Walkowiak, B., von Gries, N., O'Brien, M., Diaz Lopez, F.J., Bastein, T.	Summary of WP1 and WP2

Annex II: POLFREE Vision for a Resource-Efficient Europe in 2050