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D2.2
A Vision for a Resource Efficient Economy

WP 2 – New Concepts and Paradigms for Policies for Resource Efficiency

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1 Introduction

1.1 A Vision for a Resource Efficient Europe

Within the POLFREE project, Task 2.2 aims to establish a vision with clear and shared goals for a sustainable, resource-efficient economy in Europe. As the Description of Work points out, sharing a vision with others and incorporating their visions is an essential tool for making a vision responsible and broadly acceptable. Building such a vision for a resource-efficient Europe will provide the basis for deriving the scenarios within the POLFREE project (in Work Package 3). The vision should provide some metrics against which a scenario and its policies can be evaluated as being "successful". It should take into account the future of Europe, some likely changes at the international scale (e.g. expanding role of China and other emerging economies, ongoing environmental change etc.). It should also take into account normative issues such as human rights and equity as well as challenges of collective goods and collective action. The following dimensions of the vision are mentioned in the Description of Work:

• Scale – system boundaries as defined by research on global safe operating space shall be aligned with the activities of and within countries and regions;
• Time – lower short to medium term gains (environmental benefits) shall encourage the development of radically new technologies and institutions with higher long-term benefits for the year 2050 and beyond;
• Property rights – managing resources as private goods and international commodities shall take into account the collective goods dimension of using the environment and research on collective action;
• Empowerment – new patterns of sustainable consumption and production;
• Beyond growth - the vision will take insights from a strand of recent growth debates including debates about de-growth to consider how economic growth may be reconciled with decoupling and change.

The task should provide written inputs into a process that will be carried out in an iterative and participatory way, involving the whole project team as well as stakeholders. This includes a visioning workshop with selected key stakeholders and follow-up consultations that will establish qualitative and quantitative targets for the 2050 POLFREE vision. The final version of the vision should be guided and evaluated by its potential to trigger action and change.

Improving resource efficiency - the main focus of the POLFREE Project - is certainly one of the important strategic goals for the upcoming decades in Europe. It is embedded in Europe's 2020 Vision, Europe's growth perspective for the next decade. However, resource efficiency by itself will not be enough to ensure enduring prosperity, if it does not balance environmental objectives with human well-being. The 2050 vision needs to be not only environmentally sustainable, but also socially and economically viable. Therefore, this deliverable proposes a bold systemic vision for Europe that is grounded in ambition, which will be the basis for further elaboration and exploration in other work packages of the project.

1.2 An outline of this Deliverable

In this chapter the background for the POLFREE vision is presented, including a discussion of visions in general and the process by which the vision has been developed within the POLFREE project. Chapter 2 presents the results of a literature review on other visions published in recent years. The targets for the vision are discussed in detail in Chapter 3, followed by the discussion of the visualization process in Chapter 4. One example of a vision is presented in Chapter 5 and Chapter 6 concludes the deliverable with a reflection on the results in the light of the original objectives and the further process of developing scenarios to achieve this vision.

1.3 The process of developing a vision in the POLFREE project

The beginning of the process within the POLFREE project followed two parallel tracks. The characterization of visions provided inputs to the discussion of the kind of vision to be produced in the project. At the same time, a more detailed literature review of existing visions was carried out (Chapter 2). Vision elements from the literature review were compiled into a draft vision and circulated and discussed among project partners. The outcome of this discussion is presented in Chapter 5. More attention was then paid to the quantitative endpoint of the vision (Chapter 3).

The visualization process, carried out by Robert Horn (Macro VU Analytics) and described in Chapter 4 was an iterative process of producing drafts of the vision and discussions among the POLFREE team. At two internal project meetings in October and November 2013, the vision and the visualization were discussed in detail with subsequent revisions of the visualization.

On December 9th 2013 a stakeholder meeting was held in Brussels, organized by SERI and UCL. The vision and the visualization were discussed by the stakeholders. The list of participants in this meeting is provided in Annex I of this deliverable. Annex II summarizes the main comments made by the stakeholders. These comments were discussed in the subsequent project meeting and iteratively by the project team and taken into account in further drafts of the vision and visualization.

2 Literature Review

2.1 Step 1 – Literature review and selection of existing sustainability visions

The POLFREE project aims to build a vision with clear and shared goals for a sustainable, resource-efficient economy in Europe. It is supposed to be rooted in and deriving from what has been the output of the literature review of existing sustainability visions. To date only a few attempts have been made to create a vision with regard to resource efficiency[1].

To develop the POLFREE vision on resource efficiency, the project team started off by identifying and analyzing more general "sustainability visions" that have emerged in the last few decades. The following sustainability visions were selected:

1. Vision 2050 – the new agenda for businesses[2] (WBCSD, 2010)
2. World in Transition[3] (WBGU, 2011)
3. Europe 2020 – a strategy for smart, sustainable and inclusive growth (European Commission, 2010)[4]
4. Our Common Journey [5](The Board on Sustainable Development of the National Research Council, 1999)
5. Getting into the Right Lane for 2050[6] (Netherlands Environmental Assessment Institute, 2009)
6. The Great Transition – The Promise and Lure of the Times Ahead[7] (Paul Raskin et al. - Tellus Institute, 2002)
7. GEO 5[8] (UNEP, 2012)
8. Planet 2050[9] (Jill Jäger and Sarah Cornell, 2011)
9. The World We Made[10] (Jonathon Porritt , 2013)

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[1] E.g.: Cambridge Econometrics (2011): Sustainability Scenarios for a Resource Efficient Europe. Final Report prepared for European Commission, DG Environment; Bringezu and Bleischwitz (2009). Sustainable Resource Management. Global Trends, Visions and Policies; WRAP Report (2009). Securing the future. The role of resource efficiency. Available at: http://www.wrap.org.uk/sites/files/wrap/Securing%20the%20future%20The%20role%20of%20resource%20efficiency.pdf

[2] WBCSD (2010). Vision 2050 – the new agenda for businesses. Available at: http://www.wbcsd.org/pages/edocument/edocumentdetails.aspx?id=219&nosearchcontextkey=true

[3] WBGU (2011). World in Transition. Available at: http://www.rivm.nl/bibliotheek/rapporten/500150001.pdfhttp://www.wbgu.de/fileadmin/templates/dateien/veroeffentlichungen/hauptgutachten/jg2011/wbgu_jg2011_en.pdf

[4] European Commission (2010). Europe 2020 – A European Strategy for smart, sustainable and inclusive growth. Available at: http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf

[5] Board on Sustainable Development, National Research Council (1999). Our Common Journey: A Transition Toward Sustainability. Washington, DC: The National Academies Press.

[6] Netherlands Environmental Assessment Agency (PBL). Getting into the right Lane for 2050. Available at: http://www.rivm.nl/bibliotheek/rapporten/500150001.pdf

[7] Paul Raskin et al. (2002). The Great Transition – The Promise and Lure of the Times Ahead. Stockholm Environment Institute. Tellus Institute.

[8] UNEP (2012). Global Environmental Outlook - 5. Available at: http://www.unep.org/geo/pdfs/geo5/GEO5_report_full_en.pdf

[9] Jill Jäger and Sarah Cornell (2011). The Planet in 2050: The Lund Discourse of the Future. Routledge Studies in Ecological Economics.

[10] Jonathon Porritt (2013). The World We Made: Alex McKay's Story from 2050. Phaidon Press.

10. Randers 2052[11] (Jorgen Randers, 2012)

These visions were chosen because firstly, the team perceived them as representative for the huge variety of different sustainability visions that have been written so far (from conventional to unconventional) and secondly, this selection includes some of the most famous visions among the field of sustainable development. Moreover, the team aimed at compiling a set of visions that contains both extremes of visions, such as very descriptive, conventional, political and technically oriented ones as well as very unconventional, visionary, utopian and cosmopolitan ones. Since the POLFREE project is about the development of suitable policy mixes for a transition towards a resource-efficient Europe, special attention was given to the governance approaches put forward in the different visions. In order to cover a great variety of approaches, both bottom-up and top-down visions are included in the selection. Other criteria for the selection of the visions were the time horizon, from 2020, with a preferred horizon of 2050 and beyond and the geographic scale, covering the EU, or system boundaries of the EU (e.g. global). Lastly, attention was given to the fact that the topic of natural resources was addressed in one way or the other, when selecting the visions.

The resulting selection of 10 sustainability visions that are relevant to the development of the POLFREE vision is presented in Box 1. The visions are presented as brief overviews summarizing the main characteristics:

- Name of vision
- The Institution who published the vision
- Author (if relevant)
- Contributors to the vision
- Number of pages
- Publishing year and target year of vision
- Short summary and general assessment of the content

Box 1: Overview of 10 selected Sustainability Visions of interest to POLFREE

1. "Vision 2050 – the new agenda for business" (WBCSD)

Published by: World Business Council for Sustainable Development (WBCSD)
Contributors: WBCSD, PricewaterhouseCoopers and Accenture in cooperation with 29 international companies.
Number of pages: 80
Year: 2010 – targeted year: 2050

Two scenarios – business as usual and a sustainable world in 2050 – are compared in "Vision 2050 – the new agenda for business". The business-as-usual outlook is based on current data and prognoses of various global institutions. The second scenario, which is the actual vision, describes a sustainable future based on a mix of prognoses done by different global and national institutions, organisations as well as governments. Promising pathways (described along nine core topics) to a sustainable world in 2050 are elaborated, by highlighting

[11] Jorgen Randers (2012). 2052: A Global Forecast for the Next Forty Years. Chelsea Green Publishing.

economic, ecological and social opportunities for businesses if they invest in the areas of the suggested transition process. More particularly, this means crucial changes in various issues, such as governance structures (new policies), economic frameworks (new GDP), business strategies (new business models) and human development (change of values). Consequently these changes will lead to new and sustainable lifestyles, which are not only necessary and feasible, but will also offer tremendous business opportunities.

2. "World in Transition: A social contract for sustainability" (WBGU)

Published by: German Advisory Council on Global Change (Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen / WBGU)
Contributors: members of the council (Chair: Prof. Dr. H.J. Schellnhuber, CBE)
Number of pages: 420
Year: 2011 – targeted year: 2050

With respect to the global warming limit of 2 degrees Celsius the WBGU delivers with the "World in Transition" a clear statement towards a transformation into a low-carbon society that is essential, and, most important, technically and economically feasible. Future changes have to reach far beyond technological and technocratic reforms and call for deep systemic transformations. A new "Global Social Contract" represents the core development in this regard, which combines responsibility towards future generations with a culture of democratic participation and serves as a common basis of a societal consensus about the qualifying and determining features and paradigms of transition. The concept of Global Social Contract is a mixture of societal top-down and bottom-up processes that qualifies the means of transition. It is based on the concept of the collective responsibility for the avoidance of global warming, environmental pollution and climate change of all people (i.e. individuals and civil societies, states and the global community, as well as the economy and science). Consequently, the key driver for a societal change towards a post-fossil society is a cultural change (attentiveness instead of short-term orientation).

3. "Europe 2020: A European strategy for a smart, sustainable and inclusive growth" (EU 2020)

Published by: European Commission and Council
Contributors: European Commission and Council, but also the Member States.
Number of pages: 35
Year: 2010 – targeted year: 2020

The "Europe 2020" paper of the European Commission is neither a study nor a vision. Instead, it is a conventional policy paper that deals with future strategies of European politics and economic adjustments. The transition strategy for achieving a vision of Europe's social market economy for the 21st century consists of fostering a smart (i.e. knowledge- and innovation-based economy), sustainable (i.e. a resource-saving, ecological and competitive economy) and inclusive economy (i.e. a high-employment economy delivering social and territorial cohesion) delivering high levels of employment, productivity and social cohesion. Europe could overcome current problems and crisis if it acts collectively as a Union. Based on currently existing economic problems, environmental challenges and societal conditions, the European Commission provides solutions to meet expected future challenges based on: the successful implementation of 7 key initiatives, collaboration, cooperation and participation of

all European institutions, committees, councils, entities and member states (by Country Reporting) as well as all stakeholders involved (including civil society).

4. "Our common journey: A transition towards sustainability" (OCJ)

Published by: Board on Sustainable Development of the National Academy of Sciences and the National Academy Press.
Contributors: Governing Board of the National Research Council, the National Academy of Sciences, the Mitchell Energy and Development Corporation as well as the George and Cynthia Mitchell Foundation.
Number of pages: 384
Year: 1999 – targeted year: 2020

Based on two documents – the reports of Brundtland Commission (Brundtland Report, 1987) and the RIO `92 summit – OCJ draws a negative vision of the future world: life support systems are damaged,
hunger and poverty are increasing, steady shortfalls in water supply, and the frequency of serious natural disasters is accelerated. Backcasting from this negative future, OCJ identifies challenges to be met (fertility reduction, urban systems, agricultural production, energy and material use, ecosystem restoration and biodiversity conservation), actors that must act (policy-makers, scientists, technology experts, educators) and pathways that evolve in process and cannot be set in advance. The guidance to prevent such a negative future is led by trial and error, experimentation and social learning, integrated assessment models (to inform policy-making), scenarios (to organize scientific insight, to challenge imagination) and regional information systems (for communication to non-specialists).

5. "Getting into the Right Lane for 2050" (GIRL)

Published by: The Netherlands Environmental Assessment Agency (PBL) in collaboration with The Stockholm Resilience Centre and Stockholm University.
Number of pages: 106
Year: 2009 – targeted year: 2050

"Getting Into the Right Lane" takes statements of model-based analyses provided by IPCC, FAO, UNEP and OECD reports as a baseline to draw a negative image of the world in 2050. The main challenges identified by GIRL are poverty, hunger, biodiversity loss and climate change. It discusses critical issues, such as: producing food for a global population of nine billion people while minimising biodiversity loss; mitigating climate change process while enhancing energy security for Europe; as well as establishing practical solutions for a Europe-wide transport system that is low carbon. A crucial element of the pathway in this regard is the implementation of a power grid that allows citizens to become electricity producers by themselves (energy-autarchic) and helps to ensure a dependable supply of electricity for all.

6. "The Great Transition: The Promise and Lure of the Times Ahead" (GT)

Published by: Tellus Institute and the Great Transition Initiative
Contributors: Paul D. Raskin, Tariq Banuri, Gilberto Gallopin, Pablo Gutman, Al Hammond, Robert Kates and Rob Swart.
Number of pages: 111

Year: 2002 - target year of vision: 2084

"The Great Transition" is the narrative of a post-scarcity world at the end of the 21st century. In 2084 the Great Transition already occurred and the world is different from today. The concept of nations is past. Instead, three types of regions (Agoria, Ecodemia and Arcadia) represent the new planetary society and world community living under the values of the new World Constitution (based on the universal principles of human rights, peace, development and environment). All three regions are characterized by a high degree of political participation, a high level of quality of life, high social cohesion, no absolute poverty, human solidarity and high ecological sensibility. Societies are generally disarmed and share responsibility on a global level. Regional autonomy is stimulated on the one hand, but in its room to manoeuvre they are constrained by the need to conform to global principles and agreements (constrained pluralism – "unity in diversity"). The economic flow of material resources has significantly declined and consumption patterns have changed, leading to a dematerialization of lifestyles.

7. "Scenarios and Sustainability Transformation" (GEO-5)

Published by: UNEP
Coordinating Lead Authors: Begum Ozkaynak. Laszlo Pinter, Detlef van Vuuren
Number of pages: 37
Year: 2012 - target year of vision: 2050

Chapter 16 of UNEP's Global Environment Outlook (GEO-5) shows that meeting an ambitious set of sustainability targets by 2050 is possible. However, current supporting policies and strategies are not adequate to achieve this. Comparing a business-as-usual scenario with a vision for 2050 shows that the transition to a sustainable world requires effective implementation of wide-ranging technical and policy measures, supported by a shift in underlying motivations and value patterns. Furthermore, broad-based social contracts grounded in jointly developed visions of a sustainable future would support the inclusion of key stakeholders. Achieving the complex transformation requires a gradual but steadily strengthening transition process.

8. "The Planet in 2050" (Planet2050)

Editor: Jill Jäger and Sarah Cornell
Contributors: Participants in a workshop held in Lund in October 2008
Number of pages: 105
Year: 2010 - target year of vision: 2050

This vision was produced at a workshop in 2008 as part of the interdisciplinary Fast Track Initiative of the International Geosphere-Biosphere Programme. Participants were from academia and the sustainability practice community who provided a wide-ranging, multicultural, transdisciplinary set of perspectives. The book describes the starting point in 2010. It then provides a detailed vision for 2050 and pathways for achieving that vision. It ends by considering the challenges those pathways pose. The vision for 2050 is visualized as a wheel, with ecosystem health at the centre and societal health and human health around the outside. The spokes of the wheel are governance, beliefs, economy, education and creativity. Thus the vision is elaborated with the underlying assumption that ecosystem health is the

basis for achieving all other elements and, using the analogy of the wheel, if one of the spokes is broken the wheel will not work.

9."The World We Made"

Published by: Phaidon Press
Author: Jonathon Porritt
Number of pages: 318
Year: 2013 - target year of vision 2050

This book tells the story of "how we got our world back from the brink of collapse to where we are now in 2050". Richly illustrated with pictures of the world in 2050 and backed up with explanations of the transformations that have taken place, this book describes all aspects of the vision for 2050. With a timeline that includes the Houston Accord on Climate Change in 2020, an International Financial Transaction Tax coming into force in 2022, global food riots in 2032 and climate change disasters in 2045, Jonathon Porritt describes the many social and technological innovations that have made the world a better place to live in 2050.

10. "2952 – A global forecast for the next forty years" (Randers 2052)

Published by: Chelsea Green Publishing
Author: Prof. Jorgen Randers
Contributors: More than two dozen experts working in ecology, political science, industry, and economics
Number of Pages: 416
Year: 2012 – Target year of vision: 2052

This book was published as a report to the Club of Rome, in commemoration of the 40th anniversary of Limits to Growth (1973). It is not a vision, detailing out a positive future, but rather an objective forecast of the year 2052, taking into account planet earth's resource limitations. Jorgen Randers (climate strategy, BI Norwegian Business School) forecasts changes in population, consumption, energy use, emissions, quality of life, and climate over the next 40 years. He argues that the global population and GDP growth over the next 40 years will be slower than most expect, but not slow enough to avoid greenhouse gas emissions. Thus, the global average temperature will be pushed above the internationally agreed 2 degree threshold, turning climate change to crisis levels and destroying wild nature almost everywhere. These consequences in turn cause a reduction of well-being, especially in the rich world. Regional scenarios highlight the distribution of benefits and costs from climate change across the globe, underscoring the distinct consequences on the developed and developing world. The author emphasizes that short-sighted decision making associated with democracy is ill suited to handle climate change, given its long-term outcomes. Randers uses mathematical models and statistics to support his ideas.

2.2 Step 2 - Identification of POLFREE Vision Elements

For a more thorough assessment of the selected visions and the identification of the key vision elements of the POLFREE vision, the project team established a common analytical

framework in a second step (see ANNEX 3). The framework establishes two major analytical pillars for assessing the existing visions in more detail:

Nature
Wellbeing and Quality of Life

These two pillars are again divided into analytical sub-elements. The pillar on "**Nature**" is divided into the four basic resource categories:

a) Biotic Resources (biomass, fossil fuels)
b) Abiotic Resources (metals, minerals)
c) Water
d) Land

The Pillar on "**Wellbeing and Quality of Life**" is divided into the following sub-categories:

a) Basic Human Needs (subsistence, protection, health)
b) Security (internal and external, protection)
c) Identity
d) Social Interaction (affection, participation, creation, understanding)
e) Freedom (idleness, creation, transcendence)

The results of the analysis of each of the visions according to the common analytical framework were consolidated at an internal workshop in July 2013. Through different participatory methods the workshop aimed at extracting those main elements of the 10 selected visions that were thought to be relevant for the development of the POLFREE vision. A summary of these elements is presented in Table 1. These elements serve as a basis for the subsequent development of the vision presented in Chapter 5 and pathways (Deliverable Task 3.2). The discussion of basic human needs has also been picked up in Task 1.6 of the POLFREE project.

Table 1: Elements of existing visions of interest to POLFREE	
Values e.g. One World, people, planet Diversity Value of nature taken seriously Keep products longer Human rights	**Development** e.g. Equality Health Basic needs Distribution of wealth
Governance e.g. Transparency Living within limits New forms of democracy Multi-level, polycentric governance New models of governance, adaptive governance	**Economy** e.g. True pricing – internalization of external costs New definitions of prosperity, success, progress Resource productivity Closed loops Tax on Labour down; tax on resources up
Open Knowledge Society and Education	**Energy**

e.g. Agenda for new skills and jobs Knowledge – not only of scientists Traditional and indigenous knowledge Skills not just fact	e.g. Low-carbon economy Profound system change Balanced bio-economy Universal access to modern energy Efficiency
Buildings and Housing e.g. Low energy Renovation Urban mining Public buildings and infrastructure Steady Stocks	**Transport and mobility** e.g.Modal change towards public transportation Tele-working Mobility needs of older people Car sharing Goods transport
Resources e.g Products – long-lived, use rather than possession Closed loops and cascades Multi-stakeholder innovation Creativity New Business Models	**Land use** e.g. Reduce food waste Restoration Urban agriculture Eco-efficient, diversified agriculture Closed loops also in agriculture (e.g. compost)
Forest e.g. Stop deforestation in South Halt forest degradation R&D (adaptation to climate change) Mixed forests Certified forestry No illegal imports of timber	**Water** e.g. Improve quality Quantity – reduce water stress Improve irrigation efficiency

3 Resource Efficiency within the Safe Operating Space

3.1 Introduction: Quantifying the Endpoint of the POLFREE Vision

Within the POLFREE project, Task 2.2 aims to establish a vision with clear and shared goals for a sustainable, resource-efficient economy in Europe. It is rooted in and deriving from what has been the output of the literature review of existing sustainability visions described in Chapter 2. The vision should also provide some metrics against which a scenario and its policies can be evaluated as being "successful" (POLFREE DoW).

This chapter provides these metrics and explains how they were derived. Its aim is to set out the physical and material endpoints of the vision based on the aspirations and targets of existing resource efficiency scenarios, e.g. the Roadmap to a Resource Efficient Europe. In order to arrive at set of POLFREE targets, the team analyses of the (in)consistencies contained within the different existing resource scenarios and their targets, visions, their worldviews, the extent to which they converge or diverge, the realism of their assumptions according to current understandings of the topics. If necessary POLFREE comes up with new assumptions, with the justification as to why they have been adopted. The final product of the analysis done in this chapter is a table of 8 metrics, two for each of the four main resource categories, one on the demand side an one on the supply side. These metrics serve as physical or material endpoints of the POLFREE 2050 vision against which the success of the three different scenarios and their corresponding policy mixes can be evaluated.

The endpoints of the POLFREE Vision are based on European Commission's Roadmap to a Resource Efficient Europe[12] and the Vision 2050 of the World Business Council for Sustainable Development[13] complemented where necessary by elements of other visions published in recent years as well as by scientific assessments (e.g. by the International Resource Panel) to determine what the physical boundaries to a resource-efficient Europe vision are. The two main basis documents were selected due to their actuality and because one represents a bottom-up and one a top-down approach to visualizing a 2050 world in which resources are used in a more efficient manner.

The Roadmap to a Resource Efficient Europe outlines how Europe's economy can be transformed into a sustainable one by 2050. It proposes ways to increase resource productivity and decouple economic growth from resource use and its environmental impact. It illustrates how policies interrelate and build on each other. As stated in the EC Roadmap:

"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."

[12] European Commission (2011). Roadmap to a resource efficient Europe. Available at: http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf
[13] WBCSD (2010). Vision 2050 – the new agenda for businesses. Available at: http://www.wbcsd.org/vision2050.aspx

On December 9th 2013 the endpoints developed by the POLFREE project team were discussed with relevant stakeholders from politics, science, civil society and business in a workshop that was held in Brussels organized by SERI and UCL. A visualization of the endpoints, the logic behind the POLFREE vision and three major stages of decision-making (see Chapter 4) served as a basis for the discussion. The stakeholder's main comments were summarized (see Annex 2), discussed in a subsequent project meeting and taken into account iteratively by the project team in further drafts of the POLFREE endpoints (Chapter 3), vision (Chapter 5) and visualization (Chapter 4).

Box 2: Indicators

Material flow analysis (MFA) comprises a group of methods to analyse the physical flows of materials into, through and out of a given system. At the economy-wide level it provides the basis for deriving indicators on the metabolic performance of countries in terms of material inputs and consumption (resources domestically extracted + imports – exports).

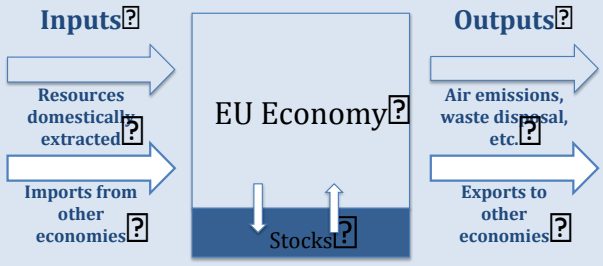

Figure: Scope of Material Flow Analysis
Source: O'Brien et al. 2011[14] based on Eurostat 2009[15]

As regards indicators relevant for resource efficiency, three basic pairs of indicators are distinguished, depending on whether indirect flows and unused extraction are taken into account:

Indirect flows (ecological rucksacks) are the up-stream material requirements of imported or exported products which are used as material inputs along the production chain, but do not cross national borders. Evidence suggests that indirect flows are increasing at a greater rate than direct flows[16].

Unused extraction describes the excavation of natural material in order to get access to more precious materials. It includes e.g. the overburden in mining, harvest residues in agriculture and forestry as well as the by-catch in fishing. As resources become more difficult to access, unused extraction grows.

[14] O'Brien, M. et al. (2011). Resource Efficiency in European Industry. Report prepared for the European Parliament's Committee on Industry, Research and Energy (ITRE). European Union. http://www.europarl.europa.eu/studies

[15] Eurostat (2009). Economy wide material flow accounts: compilation guidelines for reporting to the 2009 Eurostat questionnaire. Version 01. Eurostat.

[16] While global trade increased around 3.5-fold between 1960 and 2005, the ecological rucksacks of those traded goods multiplied by a factor of nearly 4.8 (Dittrich et al. 2011).

The simplest input and consumption indicators are Direct Material Input and Domestic Material Consumption as they only take direct flows into account. The second set of indicators -- Raw Material Input and Raw Material Consumption -- includes consideration of indirect flows. Total Material Requirement and Total Material Consumption are the most comprehensive indicators, taking into account both indirect flows and unused extraction. Productivity and intensity are measured by setting any of the indicators in relation to GDP.

	Input		Consumption	
	What are the resource requirements for production and consumption?		*What are the resource requirements for consumption?*	
	Indicators	**Derived by**	**Indicators**	**Derived by**
	Direct Material Input (DMI)	Domestic extraction used + imports	Domestic Material Consumption (DMC)	DMI - exports
	Raw Material Input (RMI)	DMI + ecological footprints	Raw Material Consumption (RMC)	RMI + exports (incl. ecological rucksacks)
	Total Material Requirement (TMR)	RMI + unused domestic extraction + resource requirements of imports	Total Material Consumption (TMC)	TMR + exports + indirect flows associated with exports

3.2 Targets

Targets set a clear orientation, provide concrete guidance and help to prioritize actions to achieve a certain policy objective. If properly enforced and supported by an appropriate policy-mix (see POLFREE Task 2.3) to ensure fair global market conditions and a level playing field, targets can be a powerful approach to addressing environmental issues. Long - term objectives provide actors in society, e.g. governmental organizations and companies, with certainty, stability and time to achieve the target in the most efficient manner.

The European Resource Efficiency Roadmap[17] aims at identifying a set of policy targets for the four key thematic areas of materials, water, land and carbon. In their latest set of recommendations, "Action for a Resource Efficient Europe"[18], also the European Resource Efficiency Platform (EREP)[19] emphasizes the importance of target-setting for guiding the EU's political action towards a resource efficient economy.

As regards material flows, two main entry points for the discussion on resource targets can be identified: the input side -- i.e. the environmental impacts of resource extraction -- and the

[17] European Commission (2011). Roadmap to a resource efficient Europe. Available at: http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf

[18] European Commission (2013). European Resource Efficiency Platform. Action for a resource efficient Europe. Available at: http://ec.europa.eu/environment/resource_efficiency/documents/action_for_a_resource_efficient_europe_170613.pdf

[19] http://ec.europa.eu/environment/resource_efficiency/re_platform/. The Platform's aims at giving guidance to the European Commission, Members States and private actors on the transition to a more resource-efficient economy. Members include European Commissioner Potočnik, Vice-President Tajani, Commissioners Hedegaard, Šemeta and Rehn, members of the European Parliament (MEPs), ministers, business CEOs, academia and representatives of NGOs and civil society.

output side, considering the limited absorption capacities of global ecosystems for waste and emissions arising from natural resource use. Targets for greenhouse gas emissions such as in the Kyoto Protocol are examples for an output-oriented target setting approach. Bringezu[20] argues, that sustainable resource use, and thus consumption, requires more than the control of negative environmental implications. Thus, resource targets should be set at the input side. He writes that: *"the reduction of primary material input would reduce the generic environmental pressure associated with the throughput of the socio-industrial metabolism. The gradual change in the global environment caused by steady extraction of mineral resources could thus be mitigated. This would also contribute to an internationally more balanced resource use and burden sharing, as environmental impacts in foreign countries induced by consumption activities in rich countries, in particular, would be reduced as well".*[21]

The EREP[22] also suggests that in addition to carbon (output side), targets should be set in the three key resource categories: materials, water and land (input side). The target-setting approach "will be further refined and accompanied by the Platform with a view to being integrated into the Europe 2020 Strategy and monitored in the European Semester process".[23]

In line with the EREP suggestions, POLFREE argues that in addition to carbon, resource use targets are needed to focus efforts to move Europe towards a more sustainable future. POLFREE will not develop new targets, but use targets suggested in both the European policy discussions and scientific literature. POLFREE follows the dashboard approach of the EC to include relevant targets in the areas of materials, water, land and carbon and also distinguishes between targets related to the global and territorial perspective (Table 2 provides an overview).

To be consistent with the vision of a resource-efficient Europe all targets should lead to both a level of consumption that is within the planetary boundaries and in which activities do not cause the transgression of other planetary boundaries (e.g. climate change and interruption of nutrient cycles). Thus, targets should either be directly derived from the safe operating space concept, or be tested against the safe operating space framework (e.g. to avoid problem shifting between environmental pressures).

Box 3: Safe Operating Space

The "safe operating space" is a concept introduced by Rockström et al. (2009)[24] in their attempt to identify and quantify a set of nine global biophysical boundaries. On basis of their

[20] Stefan Bringezu, 2011: Targets for Global Resource Consumption, in "Policy, Strategies and Instruments for a Sustainable Resource Use", Springer
[21] Stefan Bringezu, 2011: Targets for Global Resource Consumption, in "Policy, Strategies and Instruments for a Sustainable Resource Use", Springer
[22]European Commission (2013). European Resource Efficiency Platform. Action for a resource efficient Europe. Available at: http://ec.europa.eu/environment/resource_efficiency/documents/action_for_a_resource_efficient_europe_170613.pdf
[23] European Commission (2013). European Resource Efficiency Platform. Action for a resource efficient Europe. Available at: http://ec.europa.eu/environment/resource_efficiency/documents/action_for_a_resource_efficient_europe_170613.pdf
[24] Rockström et al. (2009). A safe operating space for humanity. Nature.

scientific understanding of the earth system, Rockström et al. have defined a "safe planetary operating space" that would allow humanity to continue to develop and thrive for generations to come, if these boundaries are respected. Currently, at least 3 boundaries have been transgressed (climate change, loss of biodiversity and nitrogen cycling) interfering with the major physical circulation systems of the planet and the underlying resilience of its self-regulatory capacities.

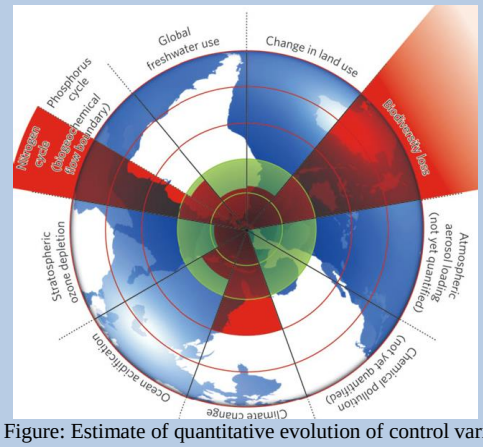

Figure: Estimate of quantitative evolution of control variables for seven planetary boundaries from pre-industrial level to the present
Source: Rockström et al. 2009

Distribution of the global safe operating space to a country-wide level is needed for target setting. POLFREE follows the concept of environmental space to attribute the access to and the use of global resources equally on a per capita basis, as is consistent with global governance of environmental limits. Hence, targets are grounded on a global justice perspective and express the EU's fair share of environmental space.[25]

Box 4: Environmental Space

The "environmental space" concept by Opschoor and F. Weterings (1994)[26] problematized the limits to the planet's resource base (the input side) as well as to its adsorption capacities (the output side), but goes one step further by additionally pointing to the global allocation question, which is related to these environmental realities.
The concept of environmental space seems simple on first sight, yet it is potentially radical in its implications. It tells us that there are limits to the rate at which we can exploit the earth's natural resources. Moreover, it points to the fact that there are even tighter limits to the amounts we can consume in Europe, if we are to share fairly with other parts of the world. In the words of Opschoor and F. Weterings (1994), "the concept environmental space, reflects that at any given point in time, there are limits to the amount of environmental pressure that the Earth's ecosystems can handle without irreversible damage to these systems or to the life support processes that they enable"[27]. The functions and services provided by the earth's ecosystem, which is a limited space, include both *stocks* (of renewable, semi- renewable and non-renewable resources) and *sinks* (capacities to absorb waste, pollution and encroachment).

[25] Opschoor, J.B., Weterings, R. 1994. Environmental utilisation space. Netherlands Journal of Environmental Sciences 9(5), 198-205.

[26] ibid

[27] ibid

The society for which the planet's ecosystem provides functions and services is of course global. As defined by Weterings and Opschoor, environmental space correspondingly refers to the space available to *humanity as a whole* for utilisation of stocks and sinks. At least, this applies to stocks that are globally tradable, and sinks that are global in their scope. Against this background, the authors point out that the recognition of global limits forces us to face the issue of how environmental space is to be *allocated* between countries and region[28].
In 2012 Raworth[29] visualized this concept by combining the safe operating space from Rockström et al. (2009) as the environmental threshold and the MDG as the social foundation for meeting basis human needs. She termed this the safe and just space for humanity.

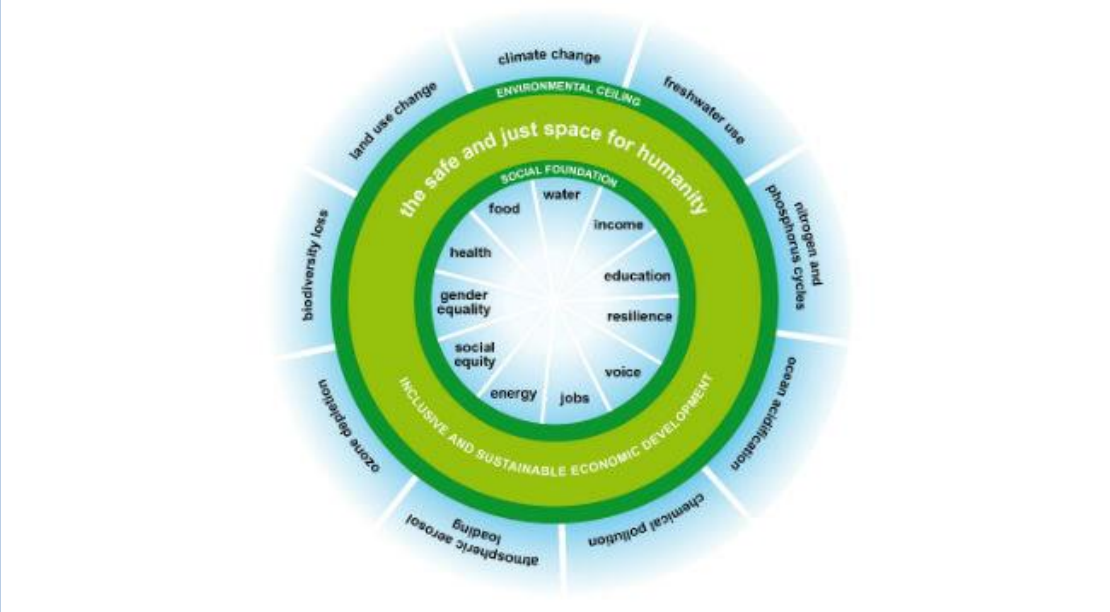

Figure: Combining planetary boundaries with social development goals
Source: Raworth 2012

As regards the consumption of global resources, one may question the need for targets with the argument that it is the responsibility of exporting countries to sustainably manage their national resource capital. This case is especially highlighted by the case of land, where conventional rights clearly define ownership at the national level and political sovereignty is usually linked to territorial autonomy. However, in a globalised world national sovereignty has to cope with international interdependencies and principles of equity and burden sharing. The shrinking and degradation of global ecosystems like forests, due to the growing consumption of biotic resources, is a national and regional, as well as a global challenge. In global terms, land use change is directly related to the planetary boundaries of climate change and the loss of biodiversity, affecting the underlining resilience of the Earth's self-regulatory capacity. Clearly, production and consumption in every country make use of foreign resources, including land, through imports and provide domestic resources for other countries' use through exports. Thus, responsibility also becomes a matter for those who consume and indirectly use others' resources, in particular when that resource use may contribute to an

[28] Hille, J. 1997. The Concept of the Environmental Space. European Environmental Agency.

[29] Raworth (2012). A Safe and Just Space for Humanity: can we live within the doughnut? Oxfam. Available at: http://www.oxfam.org/en/grow/video/2012/introducing-doughnut-safe-and-just-space-humanity#sthash.EJkBZaH8.dpuf

overuse of global capacities. This is particularly an issue for regions such as the EU as a "net consumer" of global cropland, with an increasing global cropland demand under business-as-usual. The need to monitor and control the domestic consumption of global agricultural goods toward responsible levels grows with the increasing globalization of food, feed, biofuel and biomaterial markets.[30] This holds true for other resources as well.

The POLFREE vision is based on credible, scientifically-derived and measurable headline targets for the four resource categories: materials, land, water and carbon. These POLFREE headline targets are solution-open and general; they set the end-point against which the success of a series of different resource-efficiency-pathways can be measured. They are based on the concept of a fair share of environmental space for the EU and remaining within a "safe operating space"[31]. POLFREE targets are ambitious and visionary. They show strong commitment to the promotion of resource efficiency and could contribute to mobilizing the EU, its member states, citizens and industry representatives to achieve the common 2050-goal of "living well within the planetary boundaries".

3.3 POLFREE Targets

The following table provides an overview of the POLFREE headline targets. The global perspective relates mostly to the consumption of global resources with the aim of keeping consumption levels within the safe operating space. The EU perspective reflects the state of resource use within the EU and thus also implies a sustainable management of natural capital. A range is given when appropriate (e.g. when targets are derived from literature) to test different ambitions with regards to sustainability (e.g. moderate sustainability transition to strong sustainability transition).

Table 2: POLFREE Headline Targets

Resource	Perspective	Target 2050	Sources	Rationale	Calculations
Materials	Global (consumption)	5t RMC/cap.	BIO IS 2012, Bringezu 2013 Data: Eurostat and Bringezu 2011	Returning to a global level of global raw material extraction equivalent to the year 2000 and distributing this level equally amoung the expected world population in 2050[32]	Reducing fossil fuels by 95% to meet GHG emissions targets, reducing minerals by 85% to stabilize built-up stock and halt land take, stablilizing biomass consumption and focusing on the recycling potential of metal ores.

[30] Bringezu, S., O'Brien, M., Schütz, H. (2012). Beyond Biofuels: Assessing global land use for domestic consumption of biomass: A conceptual and empirical contribution to sustainable management of global resources, Land Use Policy 29(1): 224-232

[31] Rockström et al. (2009).A safe operating space for humanity. Nature.

[32] Stefal Bringezu et al. (2013). PolRESS Arbeitspapier 1.4. – Ziele und Indikatoren für die Umsetzung von ProgRESS. Wuppertal Institut.

	EU (supply)	No net additions to stock.	BIO IS 2012	European demand for primary 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	Global (consumption)	Cropland reduced to 0.17 - 0.20 ha/person, or by 34 to 44% (compared to 2005)	• Low target: based on planetary boundary of Rockström et al. 2009[33] • High target: UNEP 2014[34] • Per capita cropland area in 2007: Bringezu et al. 2012	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	Resulting boundary in 2050 divided by expected population from UN 2012, medium variant (e.g. 0.20 to 0.17 ha per person in 2050) compared to use in 2007 (0.31 ha per person)
	EU (supply)	No net loss of cropland	Combining targets from the RE Roadmap on no net land take and on soil fertility	No net land-take (target from the Roadmap) due to expansion of built-up land and no soil degradation (implies long-term maintenance of soil fertility through good agricultural practices to	

[33] (15% of ice-free surface for cropland, or plus around 400 Mha from 2005) adjusted for population

34 The study discusses targets for 2030, which have been recalculated here for 2050. (+104 Mha net and nearly 200 Mha gross from 2005).

				ensure production over the years to come). Overarching rationale Is to prevent the loss of fertile cropland in the EU.	
Water	Global (consumption)	Mean water footprint per capita reduced 30-50% below 2004 levels	Open EU project calculated EU water footprint for 4 scenarios. Range of results used here	The water footprint covers not only the demand consumption of water directly but also the water in imported goods	
	EU (supply)	Water exploitation index below 20% in all European Countries	EU Roadmap and EEA	At 20% a region is defined as being under "water stress"	
Carbon	Global (consumption)	Mean carbon footprint per capita reduced 60-80% below 2004 levels*	Open EU project calculated EU carbon footprint for 4 scenarios. Range of results used here	Considers the impacts of goods and services imported into the EU	
	EU (supply)	GHG emissions reduced by 80 to 95% (compared to 1990)	Target from the Roadmap to a low carbon economy	To keep climate change below 2 degrees C.	<<target could be related to any base year, e.g. 2005, to make it comparable>>

3.4 Methodology

To develop the POLFREE endpoints while avoiding the risk of creating a utopia without relevance, in a first step, the project team started by identifying existing visions, scenarios and targets with an explicit focus on resource use and resource efficiency prepared by international organizations, research institutions, businesses, think tanks and NGOs. The following reports were selected as key studies:

- Roadmap to a Resource Efficient Europe [35] (European Commission, 2011)
- Vision 2050[36] (WBCSD, 2010)
- Decoupling Report[37] (UNEP IRP, 2011)

[35] European Commission (2011). Roadmap 2050. Available at: http://www.roadmap2050.eu/attachments/files/Volume1_fullreport_PressPack.pdf

[36] WBCSD (2010). Vision 2050 – the new agenda für businesses. Available at: http://www.wbcsd.org/pages/edocument/edocumentdetails.aspx?id=219&nosearchcontextkey=true

- Roadmap 2050[38] (European Commission, 2010)
- Power Perspectives 2030[39]
- Final Report for EC "Assessment of Resource Efficiency Indicators and Targets"[40] (Bio Intelligence Service)
- Final Report for EC "Sustainability Scenarios for a Resource Efficient Europe"[41] (Cambridge Econometrics)
- International Resource Panel reports on land, metals and decoupling

The selection criteria were geographical, temporal, and thematic:

- Geographical (includes European Union);
- Time horizon (2050 and beyond);
- Thematic (covers natural resources including materials (metals, minerals, fossil fuels, biomass), water, land or carbon).

In a second step, after the identification of the key studies, the project team analyzed the (in)consistencies contained with their targets, visions, their broader objectives, the extent to which they converge or diverge, the realism of their assumptions according to current understandings of the topics. This was done for each of the four major resource categories.

As a final outcome of the analysis the project team proposes a set of eight quantitative headline targets for 2050 including targets within and going beyond the scope of existing EU vision- and scenario- documents.

3.5 Introduction to overall resource efficiency objectives of different visions

3.5.1 EU overall objective

In 2011, the European Union has published a Roadmap, detailing the steps needed to implement the transition towards a resource-efficient Europe by 2050[42]. The roadmap is a key component of the "Resource-Efficient Europe Flagship Initiative", one of the sub-initiatives implementing the EU growth strategy for the coming decade, the so-called Europe 2020 strategy. By 2020, the Roadmap envisions that "Economic growth and wellbeing is decoupled from resource inputs and come primarily from increases in the value of products and associated services".[43]

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[37] UNEP IRP (2011): Decoupling Report. Available at: http://www.unep.org/resourcepanel/decoupling/files/pdf/decoupling_report_english.pdf

[38] European Commission (2010). Roadmap 2050. Available at: http://www.roadmap2050.eu/attachments/files/Volume1_fullreport_PressPack.pdf

[39] European Commission (2010). Power Perspectives 2030. Available at: http://www.roadmap2050.eu/attachments/files/PowerPerspectives2030_FullReport.pdf

[40] Bio Intelligence Service (2012): Assessment of resource efficiency indicators and targets. Final report. For DG Environment.

[41] Cambridge Econometrics (2011): Sustainability Scenarios for a Resource Efficient Europe. Final Report prepared for European Commission, DG Environment.

[42] European Commission (2011). Roadmap to a resource efficient Europe. Available at: http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf

[43] European Commission (2011). Roadmap to a resource efficient Europe. Available at: http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf

The ambitions of the roadmap are supported by the European Innovation Partnership on Raw Materials[44] which strives to "contribute to the 2020 objectives of the EU's Industrial Policy - increasing the share of industry to 20% of GDP - by ensuring the sustainable supply of raw materials to the European economy whilst increasing benefits for society as a whole"[45]. Other initiatives, such as the Eco Design Directive[46], which aims at improving the energy and resource efficiency of products in order to secure energy supply and to the reduce the demand on natural resources, likewise support the objectives of the Roadmap.

Box 5: EREP - MANIFESTO FOR A RESOURCE-EFFICIENT EUROPE

"In a world with growing pressures on resources and the environment, the EU has no choice but to go for the transition to a resource-efficient and ultimately regenerative circular economy. Our future jobs and competitiveness, as a major importer of resources, are dependent on our ability to get more added value, and achieve overall decoupling, through a systemic change in the use and recovery of resources in the economy. According to the OECD, this could lead to steady economic growth with business opportunities across the whole economy."[47]

The EU initiatives present resource efficient development as the only possible route to maintain a functioning economy, society and environment in the future. "It allows the economy to create more with less, delivering greater value with less input, using resources in a sustainable way and minimising their impacts on the environment"[48]. Thus, according to the EU, improving resource efficiency provides an opportunity to keep costs under control by reducing material and energy consumption, create new business opportunities and thus to boost Europe's innovation strength and future competitiveness. Moreover, it is supposed to ensure that the EU maintains security of supply of essential resources and limit of environmental impacts of resource use.

Although the Roadmap for the first time gives a strong signal that Europe is ready to embrace the significant environmental and economic benefits that resource efficiency brings, it has been criticized that "the plan is too vague and lacks urgent measures to reduce Europe's over-consumption of energy, water and land – which is wrecking habitats, increasing climate-changing emissions and affecting some of the world's poorest people"[49]. The roadmap adopts a traditional economic paradigm, in which economic growth is primarily achieved through technological innovations that boost resource efficiency and thus maximize utility (economic output) by minimizing costs (economic input). It describes options to move the European economy towards more resource efficiency, yet falls short of introducing innovative ideas and

[44] European Commission (2012). Raw Materials Innovation Partnership. Available at: http://ec.europa.eu/enterprise/policies/raw-materials/innovation-partnership/
[45] European Commission (2013). Strategic Implementation Plan for the European Innovation Partnership on Raw materials. Available at: http://ec.europa.eu/enterprise/policies/raw-materials/files/docs/eip-sip-part1_en.pdf
[46] DIRECTIVE 2005/32/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL (2005). Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:191:0029:0058:en:PDF
[47] European Commission (2012). Manifesto for a resource efficient Europe. Available at: http://europa.eu/rapid/press-release_MEMO-12-989_en.htm
[48] European Commission (2011). Roadmap to a resource efficient Europe. Available at: http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf
[49] FotEE (2012): Briefing Paper on Resource Efficiency Roadmap.

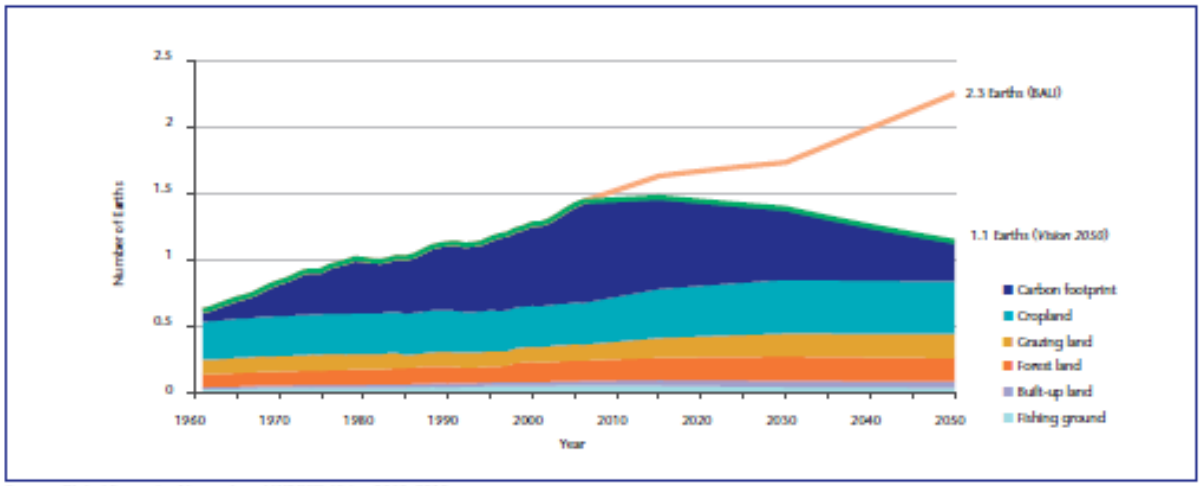
new policies for how to redefine the relationship between economic growth, material wealth and human well-being.

3.5.2 WBCSD overall objective

In 2010, the World Business Council for Sustainable Development (WBCSD) released its *Vision 2050: The new agenda for business* report. It reflects the combined efforts of CEOs and experts, and benefits from dialogues with over 200 companies and external stakeholders in some 20 countries.

In its 2050 Vision the WBCSD sets its overall objective on the decoupling of economic growth from ecosystem destruction and material consumption, and re-coupling with sustainable economic development and societal well-being. The WBCSD's *Vision 2050* promotes the viewpoint that radical changes in policy and lifestyle would, over the next forty years, make corporate environmental efficiency a competitive advantage across all industries and regions of the world. In sharp contrast to the EU Roadmap for Resource Efficiency the WBCSD provides very ambitious targets, like for example "by 2050, despite increases in population, humanity will be using the equivalent of just over one planet" (see Figure 1) and innovative policy proposals.

Figure 1: WBCSD Vision 2050 ecological footprint against business-as-usual – How many Earths do we use?



Source: Global Footprint Network and WBCSD *Vision 2050*, 2010

However, by providing calculations and estimates (see Table 3 below) to highlight that sustainability- related global business opportunities in natural resources (including energy, forestry, agriculture and food, water and metals) and health and education (in terms of social sustainability) could build up steadily, the WBCSD adopts a rather conventional view on the relation between economic growth, material wealth and human well-being. Hence, it seems that the understanding or perception of the environment and reasons for saving ecosystems is particularly driven by the idea of a warehouse of resources managed by an ecosystem service provider, maximizing agricultural yields and bio-productivity; optimizing (and not sustaining) bio-capacity and eco-efficiency; trading within ecosystem-markets under conditions of an "eco- or green race"; increasing ecosystem-services provisions, etc. All in all, this is a global vision that is quite focused on the production side with the key intervention related to price (carbon price, payment for ecosystem services, true value, etc). Consumption is hardly addressed, nor the potential savings of increasing efficiency across supply chains. The sustainability challenge presented seems to lie in finding answers to how to question of how to best maximize utilities by minimizing the costs. By contrast, POLFREE stresses the importance of considering resource limits and how to integrate targets that are linked to the concepts of planetary boundaries and the environmental space. It focuses on the role the EU plays in light of global production and consumption trends.

Table 3: Illustrative estimates of the global order of magnitude of potential additional sustainability related business opportunities in key sectors in 2050.

Sectors	Annual value in 2050 (US$ trillion at constant 2008 prices: mid-points with ranges shown in brackets)	% of projected world GDP in 2050
Energy	2.0 (1.0-3.0)	1.0 (0.5-1.5)
Forestry	0.2 (0.1-0.3)	0.1 (0.05-0.15)
Agriculture and food	1.2 (0.6-1.8)	0.6 (0.3-0.9)
Water	0.2 (0.1-0.3)	0.1 (0.05-0.15)
Metals	0.5 (0.2-0.7)	0.2 (0.1-0.3)
Total: Natural resources	**4.1 (2.0-6.1)**	**2.0 (1.0-3.0)**
Health and education	2.1 (0.8-3.5)	1.0 (0.5-1.5)
Total	**6.2 (2.8-9.6)**	**3.0 (1.5-4.5)**

Source: PwC estimates drawing on data from IEA, OECD and the World Bank

3.5.3 POLFREE overall objective

In the EU resource efficiency roadmap and the WBCSD 2050 vision, the economy grows (measured by GDP) while resource use or environmental impacts stay stable or even decline. This is widely referred to as absolute decoupling. Technological innovation and a circular economy, promoting a more efficient use of resources, are seen as the major pathway for achieving this.

For the POLFREE vision, absolute decoupling through resource efficiency is defined as a path where the European economy manages to maintain high levels of human well-being with lower resource use and environmental impacts. In theory, this concept of absolute decoupling also comprises the option of a stagnating or decreasing GDP as long as this does not affect human well-being. However, in contrast to economic growth, which is consistently measured by the GDP indicator, quantifying human well-being is a rather difficult and subjective task. Although a large number of indicators related to human well-being exist, there is now currently no consensus in academic and political debate. Hence, the operationalization of the POLFREE definition of absolute decoupling remains to be elucidated in the course of the project and in relation to the modelling results generated in WP3.

Thus, in the POLFREE project, achieving absolute decoupling through resource efficiency requires not only technological innovations, but a combination of changes in business models, citizen behaviour, and governance that rely on social, organizational and systemic innovation. The pathways will be explored in WP3. There is plenty of room for misinterpretation when discussing "pathways" to a vision. To be clear, POLFREE does not promote a centrally-planned transition process. Rather, POLFREE encourages innovation in markets, creativity in business models, and structural support for social change, without being prescriptive in the process towards a resource-efficient Europe. It is about providing the policy framework conditions to trigger structural change.

3.6 Materials

3.6.1 Current materials situation in the EU

Many of today's most pressing environmental problems, such as climate change, loss of biodiversity and pollution are caused by the overall growth of our natural resource use as

observed in the past decades. Today, humans extract more material resources than ever before in history. Growth rates in the time period after 2003 were significantly higher than in the 20 years before (3.7 % annually compared to 1.7 % per year before 2003), in particular due to the rise of emerging economies, such as China, India and Brazil. Growth has been observed in all major material categories, but is most pronounced for industrial and construction minerals and metal ores.[50]

Around 50 tonnes of resources are required per capita in the EU-27 (TMR). Around one-third is used directly, whereas around two-thirds consist of unused extraction and ecological rucksacks of imports. Between 2000 and 2007 direct material input (DMI) increased by around 5%, whereas the total material requirement (TMR) increased by 7%. This means that the resource footprints of Europeans are more than double direct material inputs, and that footprints are growing more rapidly than direct inputs.[51] In 2007, the Domestic Material Consumption (DMC) in the EU was 8.2 billion tonnes. This corresponds to 13% of the global material extraction.[52] With an average of 16.5 tonnes/capita/year the EU exceeds the global average by more than 65%.[53] Beyond that, driven by a growing materal demand, the EU is highly dependent on many material categories.

Moreover, in the EU built-up stock is constantly increasing, posing pressures on the EU's limited land area (and thus on local biodiversity as well as ecosystem services) and natural resource stocks in general. An estimate for the EU reveals that around 25% of construction minerals are used for building new infrastructure, the other 75% are used for maintaining existing stocks[54].

3.6.2 EU objectives on materials

Resource efficiency is now a key priority for policymakers across Europe — as the EU underlined when it designated resource efficiency as one of seven flagship initiatives in its Europe 2020 strategy for smart, sustainable and inclusive growth.[55]

Although the issue of unsustainable levels of resource use and waste generation is addressed as a major issue in all EU documents, quantitative reduction targets on the EU level have so far been formulated only for outputs (waste and emissions) of economic activities. However, the principal need to reduce natural resource inputs through de-coupling of economic growth from material extraction is generally highlighted as a crucial factor for achieving environmental sustainability in Europe.

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[50] DITTRICH, M., GILJUM, S., LUTTER, S. & POLZIN, C. (2012). Green economies around the world? Implications of resource use for development and the environment. Vienna.

[51] ETC/SCP (2011). Key messages on material resource use and efficiency in Europe. Insights from environmentally extended input-output analysis and material flow accounts. Assessment by D. Watson, M. Herczeg, J. Acosta, and D. Wittmer. European Topic Centre of Sustainable Consumption and Production, EEA.

[52] Bio Intelligence Service (2012). Assessment of resource efficiency indicators and targets. Final report. For DG Environment.

[53] European Commission (2011). COMMISSION STAFF WORKING PAPER. Analysis associated with the Roadmap to a Resource Efficient Europe Part II. Available at: http://ec.europa.eu/environment/resource_efficiency/pdf/working_paper_part2.pdf

[54] Bio Intelligence Service (2012). Assessment of resource efficiency indicators and targets. Final report. For DG Environment.

[55] European Commission (2011). Roadmap to a resource efficient Europe. Available at: http://ec.europa.eu/resource-efficient-europe/pdf/resource-efficient_europe_en.pdf

The "Roadmap to a Resource Efficient Europe" focuses mainly on the topic of waste generation and waste legislation considering waste as the most apparent potential for increasing resource efficiency. It aims at an absolute decline of waste generated per capita and to raise rates of recycling and re-use of critical raw materials by providing more attractive incentives for public and private actors.

The European Innovation Partnership (EIP)[56] primarily aims at reducing the import dependency of the EU. Furthermore, the EIP defines targets on raw materials (including metals, industrial minerals and construction materials, and natural rubber and wood-based materials) for 2020 which comprise further actions on exploration, mining, processing, and recycling. Furthermore, they outline the importance of creating framework conditions which foster efficiency in material use and in waste prevention, re-use and recycling and raw materials-efficient product design. In parallell, they emphasize the importance of exploring substitutes for critical and scarce raw materials. The EIP points also to the need to provide a framework for primary raw materials that would provide a stable and competitive supply from EU sources and facilitate its public acceptance. Networks of Research, Education and Training Centres on sustainable raw materials management as well as a pro-active international co-operation strategy of the EU at bilateral and multilateral level, promoting synergies with countries such as the US, Japan, Australia, Canada, Latin America and African Union are seen as a necessary requirement towards resource efficiency.

3.6.3 WBCSD objectives on materials

The main target of the WBCSD is to improve the eco-efficiency of materials on average by a factor of 10 and delivering a four-to-tenfold improvement in the use of resources and materials from 2000. Closed-loop recycling is regarded as a key strategy in terms of waste management, making landfills obsolete. Furthermore, the Vision 2050 targets an increase of the co-combustion of renewable and waste to 50% of fuel needed for industrial production and also provides raw materials for production processes. The vision also builds on an increasing acceptance of the fact that people need to limit their use of non-renewable materials e.g. to around five tonnes per person per year, down from 85 tonnes in the US in 2009. Economic growth is decoupled from ecosystem destruction and material consumption, and re-coupled with sustainable economic development and societal well-being.

3.6.4 Complementary scientific studies on materials

To reach a global stabilization of material use, BIO IS[57] in line with UNEP IRP[58] suggestions proposes a demand reduction of industrialized countries in order to allow developing countries to grow. On the aggregate level, they propose the following targets for a reduction of material use: Material use DMC is reduced by -70% by 2050. However, it is acknowledged that material use covers very diverse materials with very different characteristics. Thus, the plausibility of the overall target for DMC was cross-checked with bottom-up developed requirements on the level of the four material sub-categories (see below).

[56] European Commission (2013). Strategic Implementation Plan for the European Innovation Partnership on Raw materials. Available at: http://ec.europa.eu/enterprise/policies/raw-materials/innovation-partnership/targets/index_en.htm

[57] Bio Intelligence Service (2012). Assessment of resource efficiency indicators and targets. Final report. For DG Environment.

[58] UNEP IRP (2011). Decoupling Report. Available at: http://www.unep.org/resourcepanel/decoupling/files/pdf/decoupling_report_english.pdf

Another prominent suggestion comes from Brigezu (2011)[59]. He proposes that in light of the drastic increase of global resource extraction in the last decade, the total resource consumption per capita (TMC/$_{cap}$) should be reduced to that of the year 2000. This, he argues would come close to a per capita target of 10t TMC$_{abiot}$ in the year 2050 as an orientation for all EU countries. TMC$_{abiot}$ covers metal ores, industrial minerals and fossil fuels. In order to reach this target the resource productivity would have to be increased dramatically.

Additionally, he suggests a RMC target of 5.2t/$_{cap}$ for the year 2050 in order to reach the reduction of raw material consumption to the year 2000 level and ensure an equal distribution globally[60]. The RMC target covers all four material categories including biomass. Starting from the year 2008, Bringezu calculates that this target would imply a reduction of 68% of the raw material consumption in the EU-27. This percentage is almost identical (slightly higher) to the reduction that would be necessary to reach the 10t/$_{cap}$ TMC$_{abiot.}$ Target in 2050.

Additionally, as a key strategy to reduce resource demand, BIO IS[61] suggests that by 2050 built-up stocks in the EU should be stabilised. Stabilising built-up stocks is considered a key strategy since it results in a reduction of material use, a reduction of energy use in the production and use phase, and a reduction of the use of land. BIO IS suggests that the use of nonmetallic minerals should be reduced by about 50% by 2020 and 85% by 2050. Stabilizing built-up stocks will require boosting recycling rates and the reuse of societal stocks. Recycling potentials are expected to be substantially higher (between 80-90%) and could significantly reduce the pressure on natural stocks.[62] At the same time, to reach this target societal patterns of mobility and transport have to be changed under considerations of sustainability.

3.6.5 POLFREE discussion of different objectives on materials

According to POLFREE's overall objective by 2050, the limitations to the resource base, e.g, the limited land areas and limited productivity for biotic resources and the limited stocks for abiotic resources should be respected and the absorption capacities of the earth's ecosystem should be acknowledged and preserved. Excessive acquirement of natural resources should have been reduced and their intra-generational as well as the inter-generational distribution needs to be fair. Furthermore, the extraction of natural resources should done in the most efficient way possible[63]. Finally, a significant increase in resource efficiency considering renewable and non-renewable resources needs to be reached.

POLFREE does not set a target for the future domestic material consumption per capita in Europe, as the DMC indicator shows only part of the picture of material consumption in the EU. Especially, for abiotic materials it is essential to take into account the upstream resource requirements as well as the environmental impacts that are related to their consumption. The

[59] Stefan Bringezu (2011). Targets for Global Resource Consumption, in "Policy, Strategies and Instruments for a Sustainable Resource Use", Springer

[60] Stefal Bringezu et al. (2013). PolRESS Arbeitspapier 1.4. – Ziele und Indikatoren für die Umsetzung von ProgRESS. Wuppertal Institut.

[61] Bio Intelligence Service (2012). Assessment of resource efficiency indicators and targets. Final report. For DG Environment.

[62] Bio Intelligence Service (2012). Assessment of resource efficiency indicators and targets. Final report. For DG Environment.

[63] Bio Intelligence Service (2012). Assessment of resource efficiency indicators and targets. Final report. For DG Environment.

indicator covering these aspects is called raw material consumption (RMC). Even more comprehensive is the total material consumption (TMC) indicator, which in addition to direct and indirect material flows, covers the unused extraction that occurs when materials are extracted from the earth's crust. However, acknowledging that the TMC shows a more complete picture of material consumption in the EU, the RMC indicator is politically more accepted and hence the project team can build on a much better data situation, since the EU has already collected RMC data for all the 27 Member States (EUROSTAT). Thus, the POLFREE team decided for the RMC indicator covering all four material categories (metal ores, industrial minerals, biomass, fossil fuels) when setting a target for Europe's future material consumption. The 70% reduction of $RMC/_{cap}$ is assumed in line with Bringezu (2013) who suggested 68%, as well as BIO IS (2012) and the UNEP IRP (2011) who suggested to reduce the $DMC/_{cap}$ until 2050 by 70% from 2005 levels. A 70% reduction of $RMC/_{cap}$ in 2050 from 2005 levels in the EU is considered as the necessary extent in order to reach the desired overall objective with regards to future resource consumption that is outlined in the first paragraph of this section.

Additionally, POLFREE suggests in line with BIO IS[64] that by 2050 material stocks in the EU should be stabilized. Following this suggestion, the European demand for primary resources has to be reduced to the point that they can be nearly sourced within the built environment through e.g. urban mining. This also also implies a reduced land-take and much higher levels of reuse, recycling and renovation of the existing building stock .

However, POLFREE acknowledges that material use covers very different and diverse materials with very different characteristics. Thus, the Project teams comes up with a suggestion of how these different characteristics of these diverse materials could be translated into sub-targets after the introduction of the headline targets for material consumption in the EU in 2050.

Table 4: POLFREE Materials Headline Target

Resource	Perspective	Target 2050	Sources	Rationale	Calculations
Materials	Global (consumption)	5t RMC/cap.	BIO IS 2012 Bringezu 2013 Data: Eurostat	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[65]	17t RMC/cap in 2005 subtracted by 70%

[64] Bio Intelligence Service (2012). Assessment of resource efficiency indicators and targets. Final report. For DG Environment.

[65] Stefal Bringezu et al. (2013). PolRESS Arbeitspapier 1.4. – Ziele und Indikatoren für die Umsetzung von ProgRESS. Wuppertal Institut.

	EU (supply)	No net additions to stock	BIO IS 2012	European demand for primary resources is reduced to the point that they can be nearly sourced within the built environment through e.g. urban mining. This also also implies a reduced land take and much higher levels of renovation of the existing building stock.	

3.7 Objectives on materials: specifying different material categories for possible sub-targets

3.7.1 Defining material sub-targets: Fossil Fuels

3.7.1.1 Current fossil fuel situation in the EU

Oil, coal and gas account for more than 80% of the world energy production[66]. The energy system of the EU is, in spite of some decline in the past years, still dependent on fossil fuels. Beyond that, the dependency of the EU on import is particularly high in this sector and over 53 % of all fuels are imported[67]. In addition to the increasing trend in recent years of oil and gas dependency, the use of fossil fuels (oil, coal, natural gas and peat) leads to CO_2 emissions and therefore they are the greatest contributor to global warming, acidification, smog and toxicity. Fossil fuels are mainly used for energy production, transportation and a small amount contributes to plastic production. Currently, more than half of primary production of energy in the EU is based on fossil fuels (Eurostat, 2010) and almost the whole transport sector is supplied by fossil fuels.

3.7.1.2 EU objectives on fossil fuels

The Roadmap 2050[68] overall aim is a full decarbonization of the power sector by relying to varying degrees on renewables, nuclear and carbon capture and storage (CCS), along with a significant increase in transmission and distribution investments. A shift away from fossil fuels is regarded as absolutely essential due to resource depletion. Fossil fuels are mostly replaced in the buildings and transport sectors by decarbonized electricity and low CO_2 fuels

[66] WEO (2010). World Energy Outlook. Available at: http://www.worldenergyoutlook.org/media/weo2010.pdf
[67] European Commission (2011). COMMISSION STAFF WORKING PAPER. Analysis associated with the Roadmap to a Resource Efficient Europe Part II. Available at: http://ec.europa.eu/environment/resource_efficiency/pdf/working_paper_part2.pdf
[68] European Commission (2011). Energy Roadmap 2050. Available at: http://ec.europa.eu/energy/energy2020/roadmap/doc/roadmap2050_ia_20120430_en.pdf

(e.g., using organic waste). Demand for fossil fuels is targeted to fall by between 60% and 75%, compared to an increase in fossil fuel demand in the business as usual case. In a future with higher competition for natural resources, Europe would become less reliant on energy imports and thus become more independent. Notwithstanding a possible decline, fossil fuels still play a significant role in all pathways. Natural gas in particular plays a large and critical role through the transition.

Power Perspectives 2030[69] focuses on the transition between today and 2030 and closely follows the sectoral emissions trajectory set out by the European Commission's March 8, 2011 communication, which indicates a CO_2 emissions reduction range of around 60% for the power sector in 2030. Power Perspectives 2030 models a power system in line with the EC's emission reduction goals with a production mix with 50% renewable energy sources 11 (12% wind on-shore, 10% wind off-shore, 6% solar PV, 10% biomass, 11% hydropower and 1% geothermal), 34% fossil fuels (28% gas, 6% coal) and 16% nuclear across Europe.

3.7.1.3 WBCSD objective on fossil fuels

The nearly full decarbonization of the power sector is achieved by relying to varying degrees on renewables, nuclear and carbon capture and storage (CCS), along with a significant increase in transmission and distribution investments.
The energy mix comprises around 50% renewables and about 25% each for nuclear and fossil fuels equipped with carbon capture and storage (CCS) from 2030 onwards.

3.7.1.4 Complementary scientific studies on fossil fuels

BIO IS acknowledges that fossil fuels are directly and most significantly related to CO_2 emissions that are emitted when burning coal, oil, gas, etc. Thus, it builds its target suggestion for fossil fuels on the target for GHG emissions and energy use. The required reduction of $DMC_{fossil\ fuels}$ is then calculated as -95% until 2050. According to the BIO IS final report prepared to the EC in 2012, Europe in 2050 would appear as mostly fossil fuel free and thus potentially independent of foreign supply of energy sources.

3.7.1.5 POLFREE Suggestion for possible fossil fuels sub-target

POLFREE suggests that Europe in 2050 should be mostly fossil fuel free and thus potentially independent of foreign supply of energy sources. The Domestic Material Consumption of fossil fuels ($DMC_{fossil\ fuels}$) should be reduced by - 95 % from 2005 levels.[70]

3.7.2 Defining material sub-targets: minerals and metals

[69] European Commission (2011). Power Perspectives 2030. Available at: http://www.roadmap2050.eu/attachments/files/PowerPerspectives2030_FullReport.pdf
[70] Bio Intelligence Service (2012): Assessment of resource efficiency indicators and targets. Final report. For DG Environment.

3.7.2.1 Current minerals and metals situation in the EU

Industrial (e.g. salts, clays, chemicals, fertilisers) and construction minerals (e.g. sand, gravel, stone, gypsum, slate) together with metals are the main categories of abiotic materials.

Due to the inherent properties and implications of minerals and metals in terms of mining and quarrying, a business-as-usual consumption of other minerals will be incompatible either with a continuous supply or with acceptable levels of accumulated resource extraction and related impacts in various regions.

Today, a major concern for many industrialized and industrializing countries is the secure supply of raw materials, and the increasing expense of procuring them. Raw materials like metals and minerals are non-renewable persistent resources, which not only can become physically depleted, but also get dispersed. Their geological abundance on Earth is not so much an issue, but rather their availability geographically, technically, economically, environmentally and geopolitically[71]. The study "Critical raw materials for the EU"[72] released in 2010 by DG Enterprise and Industry, discusses several particularly important materials for the value chain e.g. among others Cobalt, Graphite, Magnesium, Beryllium, Rare Earth with "high risk" of scarcity in the EU. Supply shortages and the following consequences for the economy are the main concerns related to abiotic materials, if present extraction rates are maintained. Europe is particularly vulnerable as large shares of the raw materials for production and consumption have to be imported from abroad. Especially for metal ores e.g. iron ores the import share is 83%, for bauxite 80% and for copper 74%[73]. Their main environmental impacts relate to the high amount of energy which is needed for refining as well as. Toxicity of hazardous substances is also threatening the environment.[74]

However, for most construction materials, the EU is self-sufficient. Construction is a main driver for increasing transformation of fertile into built-up land[75].

In addition, mineral waste constitutes the majority of waste in the EU[76]. About two thirds (62 %) of the waste generated in EU-27 is mineral waste, stemming from construction and demolition activities (25-30 %) and from mining and quarrying 25 %[77]. Nevertheless the global averages of many metal recycling rates are discouragingly low and less than a third of metals have a recycling rate of over 50 percent[78].

[71] Bio Intelligence Service (2012): Assessment of resource efficiency indicators and targets. Final report, DG Environment.
[72]European Commission (2011). Critical Rew Materials for the EU. Available at: http://ec.europa.eu/enterprise/policies/raw-materials/files/docs/report_en.pdf
[73] European Commission (2011). Critical Rew Materials for the EU. Available at: http://ec.europa.eu/enterprise/policies/raw-materials/files/docs/report_en.pdf
[74] Bio Intelligence Service (2012). Assessment of resource efficiency indicators and targets. Final report, DG Environment.
[75] Bio Intelligence Service (2012). Assessment of resource efficiency indicators and targets. Final report, DG Environment.
[76] Arcadis, VITO, Umweltsbundesamt & BIO Intelligence Service (2010). Analysis of the evolution of waste reduction and the scope of waste prevention. Study for the European Commission, DG Environment.
[77] Staff Working Document with the Thematic strategy on the prevention and recycling of waste (2005).
[78] Recycling Rates of Metals (2011). A Status Report, International Resource Panel.

3.7.2.2 EU objective on minerals and metals

The Roadmap does not explicitly define targets or milestones for minerals and metals. A key strategy to become more resource efficient is by enhancing resource productivity (GDP/DMCminerals+metals) and by "turning waste into a resource"[79].

3.7.2.3 WBCSD objective minerals and metals

The WBCSD only sets targets for materials in general, including biotic ones, and focuses on reuse and recycling, rather than targeting the input side.

3.7.2.4 Complementary scientific studies on minerals and metals

Metal Ores

Although there are clear indications to reduce the use of metals, a consistent framework is lacking that would allow defining a sustainable metal use rate:

- Facing the non-renewability of metals and thus their finite availability, ecological economists like Herman Daly proposed management rules that aim the functional substitution by renewable resources: „Deplete non-renewable resources at rates that, as far as possible, do not exceed the rate of development of renewable substitutes."[80]

- The recent report published by the UNEP International Resource Panel describes that given the disappearance rate of metals in the environment, „a sustainable metals management should reduce emissions of metals to the biosphere to a level that approaches rates of geological reprocessing"[81].

Given that many metals are used because of their unique characteristics[82] their supply is regarded as critical just because of their non-substitutionability, this would in many cases mean a more complete ban for the extraction of these metals. At the same time these metals are urgently required for a variety of environmental technologies with significant potentials to increase the total resource efficiency (Moss et al. 2011, Buchert et al. 2009). Thus an optimal level of metal usage needs to take into account these integrated and dynamic aspects. Despite these conceptional challenges, studies have developed specific reduction rates for the use of metals, e.g.:

- BIO Intelligence et al. (2012): - 50% metal related DMC until 2050 in the EU
- Dittrich et al.[83] (2012): 0,8 billion tonnes metal related DMC until 2030

[79] European Commission (2011). COMMISSION STAFF WORKING PAPER. Analysis associated with the Roadmap to a Resource Efficient Europe Part II. Available at: http://ec.europa.eu/environment/resource_efficiency/pdf/working_paper_part2.pdf

[80] Daly (2005). p. 8.

[81] UNEP (2011). Recycling Rates of Metals – A Status Report, A Report of the Working Group on the Global Metal Flows to the International Resource Panel. Graedel, T.E.; Allwood, J.; Birat, J.-P.; Reck, B.K.; Sibley, S.F.; Sonnemann, G.; Buchert, M.; Hagelüken, C.p. 21

[82] „Metals and their compounds have been used in society for millenia because of their unique properties, such as conductivity,malleability, hardness, and lustre." UNEP 2013, p. 15

[83] Dittrich, M., Giljum, S., Lutter, S., Polzin, C. (2012). Green economies around the world? Implications of resource use for development and the environment. Vienna: SERI.

However, BIO IS acknowledges that setting a DMC target for metals (DMC_{metals}) makes little sense, since they account only for 4% of the EU's total DMC (in 2005).[84] However, this is due to the fact that the DMC shows only part of the picture. Especially with regard to metal products, the EU relies on imports from abroad. Countries where metals are extracted and processed suffer from high resource requirements with accompanying environmental impact. Hence, an indicator that accounts for the upstream resource requirements, which are not included in the DMC, is crucial. RMC (Raw Material Consumption) does include these. This BIO IS suggests that only once data on RMC will be available on a broader scale, a more detailed analysis of metal use can be conducted. It may then become more relevant to specify a specific target for metal RMC.

In contrast to other materials, the need for metals can also be satisfied by recycling and the provision of secondary resources. From a technical point of view „metals are the ideal type of resource for closing cycles: they do not degrade and can be recycled virtually indefinitely"[85]. Recycling is not only an approach to secure the supply of metals, secondary metallic resources also cause significantly less environmental burdens than primary resources.

Since metals are typically accumulated in societal stocks also BIO IS suggests to target recycling and reuse in order provide relief to natural stocks. Moreover, to foster a more efficient and extensive use of societal stocks, the development of technologies is required as well as improvements in product design to unfold unused potentials. BIO IS suggests that key parameters in reducing metal use are:

- Exhausting recycling potentials by technological innovation and improved product design
- Reduction of growing demand for metals by changes in consumption patterns
- Shifting towards increasing lifetimes of consumer goods
- Particularly addressing societal use of minerals with highest environmental impacts on ecosystems and human health

Given the economic incentives for improved recycling by increasing prices for many metals, the recycling rates will most probably go up for some metals. Nevertheless, it is important to see that in a dynamically developing world a recycling rate[86] does not give an indication how much of the demand can be covered by recycling. Approaching a situation where cycles of metals are indeed to a large extent closed is only possible when the demand for metals levels off: "Only in that case can secondary production catch up with the demand and will it be possible to substantially reduce primary production and therefore the energy requirement for metals production. This situation is yet far away. Developing economies are now building up

[84] Bio Intelligence Service (2012): Assessment of resource efficiency indicators and targets. Final report, DG Environment.

[85] UNEP (2011). Recycling Rates of Metals – A Status Report, A Report of the Working Group on the Global Metal Flows to the International Resource Panel. Graedel, T.E.; Allwood, J.; Birat, J.-P.; Reck, B.K.; Sibley, S.F.; Sonnemann, G.; Buchert, M.; Hagelüken, C. p. 23.

[86] Or more specifically: the end-of-life recycling rate: „The most important parameter to measure the efficiency of an overall recycling system is the functional EOL recycling rate. The func- tional EOL recycling rate excludes non-func- tional recycling flows of discarded products, and depends on the efficiency of all single steps in the recycling chain: collection, sepa- rating, sorting, and final metal recovery." UNEP 2011, p. 19.

their infrastructure, and the approaching energy transition also will lead to a growing demand."[87]

This situation will change significantly by the year 2050, for example:

- Recent metal demands will end up as stocks for "urban mining"[88].
- Products will be designed in way that allows to recover all relevant metals from products [89].

Industrial Minerals

Non-metallic minerals such as sand, gravel, limestone, clay, are mainly used for construction activities building up infrastructure (roads and buildings). This material category makes up for around half of material use.

According to BIO IS[90] an estimate for the EU56 reveals that around 25% of construction minerals are used for building new infrastructure, the other 75% are used for maintaining existing stocks. At the same time, land area is limited and the constant expansion of built-up land has to be stopped in order to reduce pressure on land area (and thus on biodiversity and ecosystem services). Stabilising built- up stocks is considered a key strategy since it results in a reduction of material use, a reduction of energy use in the production and use phase, and a reduction of the use of land. The use of non- metallic minerals should range around -50% by 2020 and -85% by 2050.

Stabilizing built-up stocks will require boosting recycling and reuse of societal stocks. Recycling potentials are expected to be rather high (between 80-90%) and could significantly reduce the pressure on natural stocks. At the same time, societal patterns of mobility and transport have to be reconsidered and further developed under considerations of sustainability.

3.7.2.5 POLFREE suggestion for minerals and metals sub-targets

Against the developments described above, POLFREE suggests that in 2050 70% of the metal demand in the EU should be covered by secondary resources (metric recycled content[91]).
The use of non-metallic minerals such as sand, gravel, limestone, clay which should be mainly used for construction activities building up infrastructure should be reduced by 85% by 2050 ($DMC_{minerals}$) in comparison to 2005 levels.[92]

[87] UNEP (2013a). Environmental Risks and Challenges of Anthropogenic Metals Flows and Cycles, A Report of the Working Group on the Global Metal Flows to the International Resource Panel. van der Voet, E.; Salminen, R.; Eckelman, M.; Mudd, G.; Norgate, T.; Hischier, R. p. 23.

[88] Brunner (2011). Urban Mining – a contribution to Reindustrializing the City. Journal of Industrial Ecology. 15(3).

[89] UNEP (2013b). Metal Recycling: Opportunities, Limits, Infrastructure, A Report of the Working Group on the Global Metal Flows to the International Resource Panel. Reuter, M. A.; Hudson, C.; van Schaik, A.; Heiskanen, K.; Meskers, C.; Hagelüken, C.

[90] Bio Intelligence Service (2012): Assessment of resource efficiency indicators and targets. Final report, DG Environment.

[91] „The metric recycled content (also termed the recycling input rate) describes the frac- tion of recycled metal (from new scrap and old scrap) in relation to total metal input." UNEP 2011, p. 19

[92] Bio Intelligence Service (2012): Assessment of resource efficiency indicators and targets. Final report, DG Environment.

3.8 Land

3.8.1 Current land use situation in the EU

Land area is increasingly exposed to increasing demand by agriculture but also built - up land and at the same time increasing pressure due to intensification of land use. Agriculture and forestry are the largest uses of land in the EU. The main pressures caused by land use through economic activities (biomass production, minerals extraction, construction and building, etc.) include fragmentation of habitats and landscapes, sealing of natural soils and land use intensity, which reduces the soil biodiversity. From an environmental point of view, unsustainable land management may lead to, for example, erosion, desertification, natural habitat loss and other threats to ecosystems.[93] Thus the challenges related to land can be characterized in two general categories: preventing undesirable land use change (e.g. conversion of forest to agriculture or urban sprawl at the cost of fertile cropland) and maintaining soil quality. These challenges are not only relevant within the EU, but also abroad to prevent problem shifting associated with European demand for agricultural products (e.g. the conversion of tropical forests into plantations to meet Europe's demand for bio-based products and fuels).

As regards cropland, the EU currently uses around 0.31 ha/person for its overall consumption of agricultural goods. This is one-fourth more cropland than available within the EU, meaning that the EU is a net importer of land. Any additional demand for biomass will contribute to land use change. Moreover, the EU-27 used one-third more cropland than the globally available per person cropland of the world population in 2007 (Bringezu et al. 2012)[94]. As regards agricultural land (cropland plus intensively used grasslands), the EU-27 "consumed" 0.45 ha per capita in 2007, which is almost one-fifth more than the domestic agricultural area within the EU.

Estimates for the EU15 revealed that 18% of domestic demand for agricultural products is supplied by foreign land. Projections for future land demand estimate an increase of global or actual land demand by 20% to 50% until 2030 (Lambin & Meyfroidt (2011)[95].

3.8.2 EU Roadmap objectives on land

The most general aim of the Roadmap for a resource efficient Europe is that by 2020 EU policies take into account their direct and indirect impact on land use in the EU and globally. Moreover, by 2020 the rate of land take should be on track in order to be able to achieve the target of no net land take by 2050. Reaching this target by following a linear path implies a reduction of land take to an average of 800 km² per year in the period 2000-2020. Additionally, the Roadmap is concerned with land quality. It aims at reducing soil erosion and increasing soil organic matter. By 2020 remedial work on contaminated sites should be well underway.

[93] Ibid.

[94] Bringezu, S., O'Brien M., Schütz, H. (2012). Beyond Biofuels: Assessing global land use for domestic consumption of biomass: A conceptual and empirical contribution to sustainable management of global resources, *Land Use Policy* 29(1): 224-232

[95] Global land use change, economic globalization, and the looming land scarcity. Proceedings of National Academy of Sciences www.pnas.org/content/early/2011/02/04/1100480108.full.pdf)

3.8.3 WBCSD objectives on land

The WBCSD vision focuses on targeting different land use categories. In 2050 forests should cover 30% of world land area. The vision focuses on a massive expansion of planted forests, but POLFREE sees limited potential for such widespread expansion in the future due to encroachment of the safe operating space for land use change. The WBCSD also foresees tremendous gains in productivity due to the application of biotechnology (including GMOs). POLFREE, on the other hand, relies on recent scientific assessments which forecast limited potential for yield increases in the future (see e.g. Hubert et al 2010[96], Bruinsma 2011[97]), also due to planetary boundaries for e.g. the nitrogen cycle being exceeded (Röckstrom et al. 2009).

Concerning the quality of land, the WBCSD aims at making the restoration of degraded land for production of food, biofuel crops and timber a common practice across the globe.

3.8.4 Complementary scientific studies on land

Röckstrom et al. on safe operating space for land use change

Röckstrom et al. (2009)[98] defined land use change as one of 9 planetary boundaries. They estimated that 15% of the ice-free land surface could be used for cropland, up from 12% in 2005. This boundary is related to the undesirable consequence of further land use change—in particular deforestation and its effects on both climate and biodiversity. This would imply that an additional expansion of roughly 400 Mha would be within the boundaries defined.

UNEP International Resource Panel

The land and soils working group of the International Resource Panel has produced a report titled "Assessing Global Land Use: Balancing Consumption with Sustainable Supply" (January 2014). It expanded on the SOS concept introduced by Röckstrom et al. by especially examining the biodiversity aspect related to land use change. This is because cropland expansion is one of the major drivers of land use change and the Convention on Biological Diversity has affirmed that the conservation of biological diversity is a common concern of humankind. Modelling results have shown that to halt global biodiversity loss the expansion of agricultural land needs to, at least, stabilize form 2020 (van Vuuren and Faber 2009). For this reason, a cautious global target of halting the expansion of global cropland into grasslands, savannahs and forests by 2020 is suggested. This would imply that business-as-usual could safely continue until 2020, at which time 1,640 Mha would be in use for agriculture (relating to a net expansion of around 100 Mha). On a per capita basis in 2030, 0.20 ha / person would be the target.

Bio-Intelligence Service on Land

[96] Hubert, B., M. Rosegrant, M.A.J.S. Van Boekel, and R. Ortiz (2010). The Future of Food: Scenarios for 2050. *Crop Science* 50: 33-50.

[97] Bruinsma, J. (2011). Land use for food, feed and fibre: the outlook to 2050 and beyond. Presentation at workshop of the International Resource Panel "Assessing global land use and soil management for sustainable resource policies". 28-29 March 2011, UNEP Paris office.

[98] Rockström et al. (2009). A safe operating space for humanity. Nature.

In their assessment of resource efficiency indicators and targets Bio Intelligence Services suggest the following targets in relation to land:

- Zero net land demand of foreign land by 2050
- Zero net land-take in the EU by 2050
- The proportions of cropland, grassland and forest in the EU are the same as in 2005
- Overall, soil organic matter levels are not decreasing and are increasing for soils with less than 3.5% organic matter in 2010
- The EU has met its target initiative for "no net loss" of biodiversity

3.8.5 POLFREE suggestions for land headline targets

Table 5: POLFREE headline targets for land

Resource	Perspective	Target 2050	Sources	Rationale	Calculations
Land	Global (consumption)	Cropland reduced to 0.17 to 0.20 ha/person, or by 34 to 44% (compared to 2005)	• Low target: based on planetary boundary of Rockström et al. 2009 (15% of ice-free surface for cropland, or plus around 400 Mha from 2005) adjusted for population • High target: UNEP 2014 (+104 Mha net and nearly 200 Mha gross from 2005) and adjusted for 2050[99] • Per capita cropland area in 2007: Bringezu et al. 2012	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	Resulting boundary in 2050 divided by expected population from UN 2012, medium variant (e.g. 0.20 to 0.17 ha per person in 2050) compared to use in 2007 (0.31 ha per person)
	EU (supply)	No net loss of cropland	Combining targets from the	No net land take (target from the	

[99] The study discusses targets for 2030, which have been recalculated here for 2050

			RE Roadmap on no net land take and on soil fertility	Roadmap) 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.	

3.9 Objectives on land: specifying different biomass categories for possible sub-targets

3.9.1 Defining land sub-targets: biomass for non food purposes - general

3.9.1.1 Current biomass for non-food purposes situation in the EU – general

Biomass for non-food purpose can be described as material of recent biological origin that can be used as a source of energy or materials. This includes wood, crops, algae and other plants as well as agricultural and forest residues. Biomass can be used for a variety of end uses: heating, electricity generation or as fuel for transportation. The term 'bio energy' is used for biomass energy systems that produce heat and/or electricity and 'biofuels' for liquid fuels used in transport[100]. The EU has a Bioeconomy Strategy for Europe[101]. It especially envisions an innovative market for new bio-based industries—e.g. for bio-based products (i.e. bioplastics), biotechnologies and biorefineries.

However, biomass has many different purposes for society (feeding humans and livestock, providing energy, use for construction purposes, etc.) and is also an integral part of ecosystems. There is a risk of pushing land use change beyond tipping points of a safe operating space to meet Europe's growing demand for bio-based fuels and materials.

[100] IRP report "Assessing Biofuels"— http://www.unep.org/resourcepanel/
[101] http://ec.europa.eu/research/bioeconomy/

3.9.1.2 EU objective on biomass for non-food purposes – general

In the 'Roadmap for moving to a competitive low carbon economy in 2050'[102] the European Council confirmed its commitment to a greenhouse gas emissions reduction of 80-95% compared to pre industrial levels. Biomass is anticipated to play a major part in achieving the 20-20-20 targets as well as the long term decarbonisation objectives. Biofuels could be used as an alternative fuel especially in aviation and heavy duty trucks, with strong growth in these sectors after 2030. For biofuels this could lead, directly or indirectly, to a decrease of the net greenhouse gas benefits and increased pressure on biodiversity, water management and the environment in general. This reinforces the need to advance in 2nd and 3rd generation biofuels and to link with the ongoing work on land use change and sustainability, in particular considering the interrelations between targets (e.g. for land and water).
The Roadmap also recognises the challenges of global food security and action on climate change that needs to be considered along with the following increased land use requirements in the EU and on a global scale.

A substantial part of the biofuels required in the EU in 2050 should be provided by a competitive European industry, using a wide range of biomass resources, based on sustainable and innovative technologies while balancing it with international biofuel trade.

3.9.1.3 WBCSD objective on biomass for non-food purposes – general

In the Vision 2050, biofuels contribute to 30% of transport energy needs, of which half come from agriculture and the remaining half from forests and other forms of biomass. POLFREE regards this as unlikely for the EU due to the increased amount of land it would require.

3.9.1.4 POLFREE suggestion for possible biomass for non-food purposes sub-target

POLFREE suggests the efficiency of biomass usage for energy and material use should be increased by 2050. In particular, organic waste should be used as a key feedstock of the bioeconomy. Moreover, energy demand should be reduced dramatically due to changes in mobility structures and investments in energy efficiency of the building stock.

In 2050 EU demand for food and non-food biomass from cropland should be within the safe operating space for cropland use. Food should be given first priority, followed by material use of biomass. Energy should be generated from biomass at the end of its life-cycle (e.g. organic waste).

3.9.2 Defining land-sub-targets: biomass for non-food purposes – wood

3.9.2.1 Current wood situation in the EU

Forests provide a number of crucial ecosystem services such as storage of carbon, watershed, wildlife habitats, biodiversity and recreational space. 30% of the EU's land area is covered by

[102] European Commission (2011). A Roadmap for moving to a competitive low carbon economy in 2050. Available at: http://eur-lex.europa.eu/legal-content/EN/ALL/;jsessionid=jJcmTxyD0f1mTt6VhKGZDPLdGGqS1zCVT6R0Fy1BP6jDlYlsLyRT!1896676610?uri=CELEX:52011DC0112

forests[103]. Almost half of the timber in the EU is used in the construction sector. About one third is used for paper and cardboard. A significant amount of paper and cardboard production in the EU depends on recovered paper supply (driven partly by recycling targets for paper). There is a growing recognition for the sustainable management of forests. Despite this, the demand for certain hardwoods is causing deforestation associated with substantial environmental impacts in sensitive areas in certain regions of the world. As a reaction, Germany and the UK, for example, has set an objective of increasing the consumption of wood from sustainable forestry. A second worrisome trend is the growth of monoculture plantations in developing countries, with respect to the planetary boundary of land use change.

3.9.2.2 EU Roadmap objective on wood

The Roadmap does not explicitly set targets for how European forests and the consumption of forest products should look like in the future. However, the roadmap's sets targets for the development of more resource efficient building sector, which indirectly influences the future demand for wood. It is stated that the Commission and its member states will promote the sustainable use of wood in construction, (Communication on the sustainable competitiveness of the construction sector, 2011, Communication on sustainable buildings, 2013).

3.9.2.3 WBCSD objective on wood

According to the WBCSD Vision, by 2050 wood prices should incorporate the value of wood products in storing carbon long-term. It is projected that the consumption of roundwood will have grown by 50% to meet an increased demand for building materials and other wood products for power generation and fuel production. It suggests meeting these additional demands through genetic improvements of trees in monoculture plantations that emphasize a mix of plant traits (drought tolerance, insect resistance, product characteristics) and adaptation to different forest types and locations. POLFREE does not judge this vision as realistic as regards the planetary boundaries regarding land use.

3.9.2.4 POLFREE suggestion for wood sub-target

POLFREE envisions a 2050 world in which the European demand for timber is within the safe operating space of global forest use. This means:

For demand levels, the flows of timber have to not only stem from sustainable production methods (e.g. sustainable harvest levels) but also that they are not contributing to an overuse of global land and forest resources (e.g. causing land use change).

For consumption levels, three factors have to be considered for both the domestic and global perspectives: area available for timber supply, productivity on that area, and sustainable harvest levels in that forest.

Aggregation of this information provides a reference value for global sustainable harvest levels in 2010, which can be divided by the world population to derive a per capita reference value for analysing timber flows. Work on how to integrate the prevention of land use change in a sustainable reference value for the future is ongoing (O'Brien forthcoming).

[103] http://www.cbd.int/countries/profile/default.shtml?country=eur

3.9.3 Defining land-sub-targets: biomass for food purposes - crops

3.9.3.1 Current crop situation in EU

The EU has a highly productive land use system and biomass extraction amounted to 1.6 billion tonnes in 2005 which corresponds to 8 % of total global biomass extraction. Crop harvest accounted for the largest share of total extraction (42 %) followed by forage and grazed biomass (31 %)[104].

Current EU land cover is 4.2 million km^2 of which roughly 44% are dedicated to agriculture[105]. The food and drink value chain in the EU causes 17% of our direct greenhouse gas emissions and 28% of material resource use. It is a major user of high-quality water[106].

Food production is dependent on the resources which are subject to the greatest risks. For its inputs it is dependent on natural systems (including clean water, fertile soil, ecosystem services from biodiversity), petrochemicals and other mineral inputs (e.g., phosphates). Problems with these resources have particularly high impacts on global markets and thus on people in developing countries and lower income groups.

According to FAO figures, more than 30% of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year[107]. However, in the EU alone, 90 million tonnes of food every year or 180 kg per person are wasted. Households are responsible for roughly 40 % of all food waste while the retail and catering sector count of another 20%[108]. Much of this is food, which is still suitable for human consumption.[109]

3.9.3.2 EU objective on crops

The "Roadmap to a Resource Efficient Europe" targets to provide widespread incentives for a healthier and more sustainable food production and consumption to reduce the food chain's resource inputs by 20%. It also points out the need to halve edible food waste in households, retailers and catering in the EU[110] by 2020.

3.9.3.3 WBCSD objective on crops

The Vision 2050 is designed to promote, on the one hand to have enough food and water for a growing population and on the other hand to provide enough biofuels to reduce GHG emissions. These targets are achieved through increased productivity by a Green Revolution which comprises improved agricultural practices, water efficiency, new crop varieties and new technologies, including biotechnologies. However, most scientific assessments conclude that yield growth is declining and that there is little space for significantly increasing the productivity of farmland in industrial countries significantly.

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[104] http://ec.europa.eu/environment/resource_efficiency/pdf/working_paper_part2.pdf

[105] Land Use/Cover Area frame Survey (LUCAS), conducted in 2009. Land was surveyed in 23 EU Member States, where both the physical cover of the land and its visible socio-economic use were recorded

[106] http://ec.europa.eu/environment/resource_efficiency/pdf/working_paper_part2.pdf

[107] J. Gustavsson et al. (2011): Global food losses and food waste, FAO.

[108] http://ec.europa.eu/environment/resource_efficiency/pdf/working_paper_part2.pdf

[109] BIO Intelligence Service (2010): Preparatory study on food waste across EU27

[110] http://ec.europa.eu/environment/resource_efficiency/pdf/working_paper_part2.pdf

3.9.3.4 POLFREE suggestion for possible crops sub-target

By 2050 share of biomass for human nutrition should be decreased due to a shift from animal-based food to higher share of plant-based food in European diets.[111]

3.9.4 Defining land sub-targets: biomass for food purposes - Livestock

3.9.4.1 Current livestock situation in EU

The meat production of the EU accounts for 15-18 % of global meat production and is almost exclusively consumed within EU. It requires large amounts of high quality protein feed which is mostly imported from countries like Brazil and the United States. Meeting the enormous demand of the European meat consumption patterns requires imports that correspond to an area of more than 20 million ha of foreign cropland.[112]

The production of 1 kilogram of meat requires several kilograms of vegetable products, depending on the livestock product. Therefore, the livestock sector accounts for 70 % of all agricultural land and 30 % of the land surface of the planet. Moreover, the livestock sector causes considerable reductions of global biodiversity through a very high land demand and therefore contributes to further deforestation.[113] At the same time it is one of the largest sources of greenhouse gases and in developed countries it is a major driver of water pollution. Hence, it is one of the major stressors on many ecosystems.[114]

3.9.4.2 EU objective on livestock

According to the Roadmap to a resource efficient Europe food choices have a significant effect on resource use. They argue that current trends of growing animal product consumption are unsustainable and not healthy and that healthier and more sustainable food production and consumption by 2020 would drive a 20% reduction in the food chain's resource inputs.[115]

3.9.4.3 3.12.3 WBCSD objective on livestock

Following the Vision 2050, a greater focus on food efficiency, security and footprint is needed to meet rising demand for food, including meat and fish. The main focus is on encompassing efficiency from field to plate as well as nutritional efficiency (e.g. grain vs. meat) and the consumption/purchase ratio of purchased food.

[111] Bio Intelligence Service (2012): Assessment of resource efficiency indicators and targets. Final report, DG Environment.

[112] FAO (2006): Livestock's long shadow, Livestock Environment And Development (LEAD) Initiative.

[113] http://ec.europa.eu/environment/resource_efficiency/pdf/working_paper_part2.pdf

[114] 2006): Livestock's long shadow, Livestock Environment And Development (LEAD) Initiative.

[115] http://ec.europa.eu/environment/resource_efficiency/pdf/working_paper_part2.pdf

3.9.4.4 POLFREE suggestion for possible livestock sub-target

In 2050, the share of biomass for human nutrition should be decreased due to a shift from animal-based food to higher share of plant-based food in European diets.[116]

3.9.5 Defining land-sub-targets: biomass for food purposes - fish

3.9.5.1 Current fish situation in EU

The main concern with fisheries is the overexploitation of fish stocks and the impacts on marine ecosystems. Production from aquaculture has increased globally. EU aquaculture only represents 2% of world aquaculture production. Despite great progress in aquaculture techniques, the EU output from aquaculture has been constant since 2000, far from the 30% increase observed in the rest of the world.[117] Low fish stocks have raised concerns of the sustainability and profitability of the fishing industry, and placed it on top of the international fisheries agenda. Nowadays, the Total Allowable Catches (TACs) for each fish stock are shared between the EU Member States according to a fixed allocation key based on their historic catches. Limiting the days which vessels can spend at sea is now a systematic element in all long-term fishery plans. A long-term commitment was also made by the EU Member States at the 2002 Johannesburg World Summit on Sustainable Development in order to bring all European fish stocks to a state where they can produce at Maximum Sustainable Yield (MSY) by 2015. As a result, the annual EU regulations setting Total Allowable Catches (TACs) and quotas for the most important commercial species are no longer simply a mechanism for dividing up a common resource. They are also called upon to provide protection and preservation of vulnerable fish populations. Despite the efforts in setting up indicators and quotas for sustainable fisheries, the Common Fisheries Policy (CFP) has so far failed to deliver healthy stocks and keep the fishing industry profitable.[118]

3.9.5.2 EU objective on fish

The EU Roadmap aims at achieving good environmental status of all EU marine waters by 2020. With regards to the quanity of fish taken from EU marine waters it aims at limiting fishing activities to stay iwithin maximum sustainable yields by 2015.

Moreover, the roadmap is targeting fish resources indirectly through the establishment of a more sustainable food production and consumption system. Accordingly, widespread incentives for a healthier and more sustainable food production and consumption will be introduced by 2020. This is supposed to drive drive a 20% reduction in the food chain's resource inputs. Disposal of edible food waste should have been halved in the EU.

3.9.5.3 WBCSD objective on fish

Also the WBCSD targets fish indirectly through a greater focus on food efficiency, security and footprint. This would allow societies to meet rising demand for food, including meat and fish.

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[116] Bio Intelligence Service (2012): Assessment of resource efficiency indicators and targets. Final report, DG Environment.

[117] http://ec.europa.eu/environment/enveco/resource_efficiency/pdf/annex_report.pdf

[118] European Commission (2009) Green Paper. Reform of the Common Fisheries Policy. COM(2009)163 final.

3.9.5.4 POLFREE suggestion for possible fish sub-targets

In 2050 fish stocks in European marine waters have regenerated through a strong control system of fish catches and an absolute reduction of fish consumption.

POLFREE suggests that by 2050 the share of biomass for human nutrition should be decreased due to a shift from animal-based food to higher share of plant-based food in European diets.[119]
On the basis on the final report on Sustainability Scenarios for a Resource Efficient Europe prepared by Cambridge Econometrics for the European Commission in 2011[120] two additional subtargets are selected:

By 2050 fish capture production [t] is below Total Allowable Catch (TAC)
By 2050 fishing is within Maximum Sustainable Yields (MSY)

3.10 Water

3.10.1 Current water situation in the EU

The main challenge of water use is balancing the supply and consumption at a local level. In Europe the availability of freshwater has become increasingly problematic as water usage is increasing in households, industries, and agricultural sectors. Energy production (cooling water) accounts for 44% of total water abstraction, 24% of abstracted water is used in agriculture, 21% is used in public water supply and 11% for industrial purposes. The combined effect of reduced levels of water availability and increased ratios of water extraction to availability leads to a growing number of river basins becoming water - stressed[121]. Water stress is measured using the Water Exploitation Index (WEI), which is the ratio of water withdrawals to water availability on the river basin level[122].

3.10.2 EU objectives on water

The Roadmap for a Resource Efficient Europe focusses on implementation of Water Framework Directive River Basin Management Plans. The aim is to achieve good quality, quantity and use of water. The quantitative milestone for 2020 in the Resource Efficiency Roadmap is to keep water abstraction below 20% of available renewable water resources.

The Staff Working Document accompanying the Roadmap[123] points to a water saving potential of 65%, reporting that model simulations in the ClimWatAdapt project[124] show that ambitious environmental policy could keep the vast majority of the EU out of water stress. According to Dvorak (2007), also referred to in the Staff Working Document, 20-40% of Europe's water is wasted and water efficiency could be improved by 40% through technological improvements alone[125]. The sustainability scenario of the ClimWatAdapt project gives a decrease in total water withdrawals of more than 25% for all of Europe.

[119] Bio Intelligence Service (2012): Assessment of resource efficiency indicators and targets. Final report, DG Environment.

[120] Cambridge Econometrics (2011): Sustainability Scenarios for a Resource Efficient Europe. Final Report prepared for European Commission, DG Environment.

[121] Bio Intelligence Service (2012): Assessment of resource efficiency indicators and targets. Final report. For DG Environment.

[122] http://climwatadapt.eu/sites/default/files/ClimWatAdapt_final_report.pdf
[123] http://ec.europa.eu/environment/resource_efficiency/pdf/working_paper_part2.pdf
[124] http://climwatadapt.eu/sites/default/files/ClimWatAdapt_final_report.pdf
[125] T. Dvorak et al. (2007) EU Water saving potential, Report for DG Environment

The EU Blueprint to Safeguard Europe's Water Resources[126] points to the need to improve water allocation and introduce water efficiency measures.

3.10.2.1 WBCSD objective on water

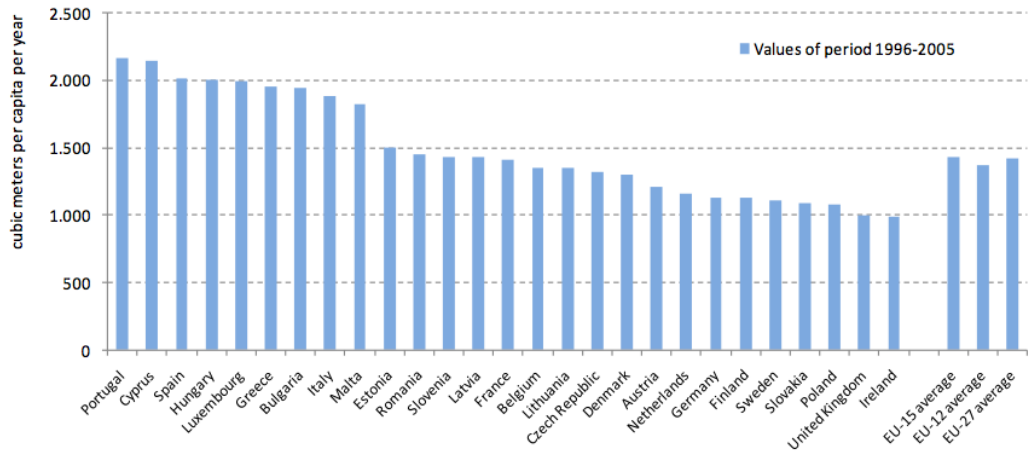
The WBCSD focuses on the agricultural uses of water with a radical reduction of water use per unit output and overall from agriculture.

3.10.2.2 Complementary scientific studies on water use

According to the resource efficiency roadmap, methodological gaps do not allow a target based on water abstraction to be formulated at the moment. The Commission is currently developing appropriate indicators to set water efficiency targets. To complete the basket of indicators, the project team referred to the EEA recommendations that water abstraction should stay below 20% of available renewable freshwater resources (Water Exploitation Index). There are many existing solutions and best practices that would allow this target to be achieved without compromising agricultural yields and fulfilling the needs of the economy. But due to a lack of data and understanding of water use at a river basin level, it is not clear how cost effective such a target would be.

With regards to limiting water consumption levels to a fair share for EU citizens BIO IS suggests the Water Footprint Indicator for blue and green water per capita for all EU countries is illustrated in the figure below.

Figure 2: Water Footprint (blue and green) per capita (Water Footprint Network, 2011)



The EU-27 average Water Footprint is about 1,400 cubic meters per capita per year. The EU-15 and EU-12 averages do not diverge much. The results for the different EU countries range from over 2,000 for Portugal to about 1,000 for Ireland. The curve of the Water Footprint is much more homogeneous compared to the data on water abstraction, illustrating that the

[126] COMMITTEE AND THE COMMITTEE OF THE REGIONS A Blueprint to Safeguard Europe's Water Resources
/* COM/2012/0673 final */ http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52012DC0673:EN:NOT

consumption patterns across Europe demand a comparable amount of (domestic and foreign) water.

The OPEN EU Project has calculated the Water Footprint for a set of scenarios. The results show that the scenarios reduce the Water Footprint by 30 – 50% in 2050 (compared to the 2005 value)[127]

3.10.2.3 POLFREE discussion of different objectives on water

Following the discussions in the Roadmap and the EEA recommendations, the target of keeping water abstraction below 20% of available renewable freshwater resources can be taken as an endpoint for the POLFREE Vision. Following the recommendation of BIO IS and using the results of the OPEN EU project, a reduction of the water footprint of 30-50% from 2005 values is taken as the end-point for the POLFREE vision.

Table 6: POLFREE headline targets for water

Resource	Perspective	Target 2050	Sources	Rationale	Calculations
Water	Global (consumption)	Mean water footprint per capita reduced 30-50% below 2004 levels*	Open EU project calculated EU water footprint for 4 scenarios. Range of results used here	The water footprint covers not only the demand consumption of water directly but also the water in imported goods	
	EU (supply)	Water exploitation index below 20% in all European Countries	EU Roadmap and EEA	At 20% a region is defined as being under "water stress"	

3.11 Carbon

3.11.1.1 Current carbon situation in the EU[128]

To prevent severe impacts of climate change, the international community has agreed that global warming should be kept below 2ºC compared to the temperature in pre-industrial times. Thus the further temperature increase should be no more than 1.2°C above today's level. To meet this goal, the scientific evidence indicates that the world must stop the growth in global greenhouse gas emissions by 2020 at the latest, reduce them by at least half of 1990 levels by the middle of this century and continue cutting them thereafter[129].

About 11% of the greenhouse gases emitted worldwide annually is from the European Union. The EU's share of global emissions is falling as Europe reduces its emissions and as those from other parts of the world, especially the major emerging economies, continue to grow.

[127] http://www.oneplaneteconomynetwork.org/resources/programme-documents/WP7_OPEN-EU_Scenario_Quantification_Report_Cover.pdf

[128] See also Section on fossil fuels

[129] http://ec.europa.eu/clima/policies/brief/eu/index_en.htm

The 15 countries that were EU Member States when the Kyoto Protocol was agreed in 1997 committed to reduce their collective emissions of a basket of six greenhouse gases in the Protocol's first period (2008-2012) to 8% below the level in their various base years (1990 in most cases). In 2011, the latest year for which comprehensive data are available, EU-15 emissions were 14.9% below the base-year level[130].

3.11.1.2 EU objectives on carbon

EU leaders have committed to transforming Europe into a highly energy-efficient, low carbon economy. The EU has set targets for reducing its greenhouse gas emissions progressively up to 2050.

For 2020, the EU has committed to cutting its emissions to 20% below 1990 levels. This commitment is one of the headline targets of the Europe 2020 growth strategy and is being implemented through a package of binding legislation. The EU offered to increase its emissions reduction to 30% by 2020 if other major emitting countries in the developed and developing worlds commit to undertake their fair share of a global emissions reduction effort.

In the climate and energy policy framework for 2030**,** the European Commission proposes that the EU set itself a target of reducing emissions to 40% below 1990 levels by 2030.

For 2050, EU leaders have endorsed the objective of reducing Europe's greenhouse gas emissions by 80-95% compared to 1990 levels as part of efforts by developed countries as a group to reduce their emissions by a similar degree. The European Commission has published a roadmap for building the low-carbon European economy that this will require[131].

3.11.1.3 WBCSD objective on carbon

Vision 2050 of the WBCSD includes a reduction of carbon emissions worldwide of 50% (based on 2005 levels) by 2050, with greenhouse gas emissions peaking around 2020.

3.11.1.4 Other relevant scientific studies on carbon

The BIO IS report on resource efficiency uses the CO_2 emissions reduction target of 95% below 2050 levels[132]. The carbon footprint of the EU was calculated in the OPEN EU project[133] for a baseline in 2004 and four scenarios for 2050. The results show that the average carbon footprint of an EU citizen is reduced in the scenarios by between 80% and 66%. The high reduction is a result of dramatic efficiency improvements and reductions in consumption, while the lower reduction is a result of a slower rate of efficiency improvement, pressure for economic growth and lower effectiveness of consumption policy.

3.11.1.5 POLFREE discussion of different objectives on carbon

For the headline targets in the POLFREE project, it is appropriate to take the EU greenhouse gas emission target of a reduction of 80 – 95%, since this is already adopted as an EU goal for

[130] http://ec.europa.eu/clima/policies/g-gas/index_en.htm

[131] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0112:FIN:EN:PDF

[132] http://ec.europa.eu/environment/enveco/resource_efficiency/pdf/report.pdf

[133] http://www.oneplaneteconomynetwork.org/resources/programme-documents/WP7_OPEN-EU_Scenario_Quantification_Report_Cover.pdf

2050. In order to include consideration of Europe's consumption within a global context, the results of the OPEN EU project are taken as a target for reduction of the EU carbon footprint.

Table 7: POLFREE headline Targets for carbon

Resource	Perspective	Target 2050	Sources	Rationale	Calculations
Carbon	Global (consumption)	Mean carbon footprint per capita reduced 60-80% below 2004 levels*	Open EU project calculated EU carbon footprint for 4 scenarios. Range of results used here	Considers the impacts of goods and services imported into the EU	
	EU (supply)	GHG emissions reduced by 80 to 95% (compared to 1990)	Target from the Roadmap to a low carbon economy	To keep climate change below 2 degrees C.	<<target could be related to any base year, e.g. 2005, to make it comparable>>

4 The Information Mural of the POLFREE Vision

4.1 Introduction

The overall aim of this info-mural is to provide a wide range of stakeholders, including people from the European Commission and the European Parliament, with a single one-page document they can post, refer to, and use to coordinate their thinking in conjunction with the several alternative pathways to achieve the resource – efficiency targets highlighted by the POLFREE project.

In one visualization it is not desirable to show all of the detail that has gone into the visioning work in the POLFREE project that this report describes. Rather, the aim here is to reflect the essence of the thought processes that drive the vision.

The information mural of the POLFREE vision was, thus, created to:

1. Show the logic of why the vision for Europe (and for the world) is needed;
2. Show the three major stages of decision-making in setting and implementing the goals of Europe;
3. Show the major targets (quantitative and qualitative) for the resource efficiency pathways for Europe to be explored in the POLFREE project.

The info-mural benefitted from a Stakeholder Workshop in Brussels (December 9, 2013) during which it was thoroughly discussed, criticized, and, as a result, modified and improved.

4.2 Why the vision for Europe (and for the world) is needed

As decision makers and the wider European public examine the next 40 years, two major considerations become prominent. The first is that Europeans wish to retain and aspire to improve Europe's quality of life. This could require considerable use of resources of all kinds, air, water, land, and materials. And, secondly, they recognize that there are significant constraints that may limit the achievement of these aspirations. These two considerations are presented in the top two bubbles on the visualization: 1) aspirations, and 2) constraints.

Aspirations

The aspirations, discussed in a stakeholder workshop, include: human security; healthy food, water & sanitation; education & healthcare for all; work-life balance & decent working conditions; equity, solidarity, & community; political & economic freedom; conservation & appreciation of the environment; access to open space & nature; security in old age; equitable society for Europe & the world; jobs & reasonable income level; comfortable homes; convenient & comfortable mobility; solidarity between countries.

Constraints

Fulfilling these aspirations depends on the use of resources of a finite planet shared with the people of other countries. Recently, global systems science has identified nine planetary boundaries[134] that characterize some of these finite resource limits. They have also established quantitative limits for seven of these boundaries. Two require more scientific investigation to establish the boundaries.

[134] Rockström et al. (2009). A safe operating space for humanity. Nature.

The same scientific team reports that three of these planetary boundaries (biodiversity loss; nitrogen cycle; and climate change) have already been dangerously exceeded as a result of human action. In addition, four more of the boundaries are being approached rapidly (ocean acidification; land-use change; global freshwater; phosphorus cycle). For only one of the boundaries is humanity going in the safe direction (ozone depletion).

These boundaries represent a requirement for European Union as well as the other countries to decrease their total resource use in order to stay within safe limits.

In addition there are two other broad classes of constraints on Europe's resource use:
*Resource Depletion and Supply Shortages.*14 critical raw materials have a high risk of supply shortage in the next 10 years. Furthermore, there is evidence of unsustainable depletion of environmental resources (fish, timber, water, fertile soils, clean air, biomass, biodiversity).
Global Interdependence. Currently 20 -30 % of the resources are imported into the EU. The EU is a "net consumer" of global cropland. Targets should be grounded on a global justice perspective and reflect the EU's fair share of environmental space.

Together, the clash of Europe's aspirations with planetary boundaries and other constraints require absolute decoupling of economic growth and resource use, which is described on the info-mural as "enabling the economy to grow while total resource use decreases."

4.3 Europe's Resource Efficiency Targets for 2050

This disparity between aspirations and availability of resources has begun a process of Europe thinking deeply about what Europe's share of planetary resource use should be. Indeed, the basic rationale for the POLFREE project is to advance research on this issue. The European Commission[135]produced a set of targets for the EU that begin to characterize the "solution space" for absolute decoupling. Many of these targets have been used as a basis for the targets that constitute the end-point of the vision in the POLFREE project. The selected targets are described in more detail in Chapter 3 of this report.

4.4 Key Characteristics for a Resource Efficient Future

These targets were then considered from the standpoint of major sectors of Europe's economy:

- *Mobility & transportation.* Fuel efficient mobility - Approx. 50% reduction in transport GHG emissions.
- *Electricity production & distribution.* Low carbon energy & reliance on renewables.
- *Construction & buildings.* All existing buildings retrofitted - Insulated and triple paned windows; efficient heating & air conditioning; and all new buildings nearly zero-energy & highly material efficient.
- *Agriculture & food.* 20% reduction in the food chain's resource inputs from 2010. Edible food waste 80 % reduced from 2010 level.
- *Refinery & chemical products.* Use of dangerous chemicals avoided

[135] European Commission (2011). Roadmap to a Resource Efficient Europe.

4.5 Range of Policies and Practices

Finally, to suggest the kinds of changes in policies and practices of the European economy that would be explored in the project, some broad classes were identified: sustainable resource & supply-chain management; fiscal & funding reform for resource-efficient governing; reform finance policy; waste prevention; new business models; eco innovation; natural capital accounting with ecosystem services valued & priced; extended producer responsibility for waste & recycling; further carbon pricing; cleaner manufacturing; new & improved lifestyle choices & changes.

4.6 The logic of the project

The info-mural "Vision for a Resource-Efficient Europe in 2050" thus presents on a single page a narrative for the POLFREE project: what Europe aspires to; what urgent constraints it (and the world) faces; what targets for its air, water, land, and materials use it must have; what these targets represent in targets for Europe's economy; and, what types of policies and practices will need to be implemented by the European Union to achieve these targets.

4.7 Design constraints

Looking at the overall problem of presenting the vision, the following design constraints had to be considered. The Vision should:

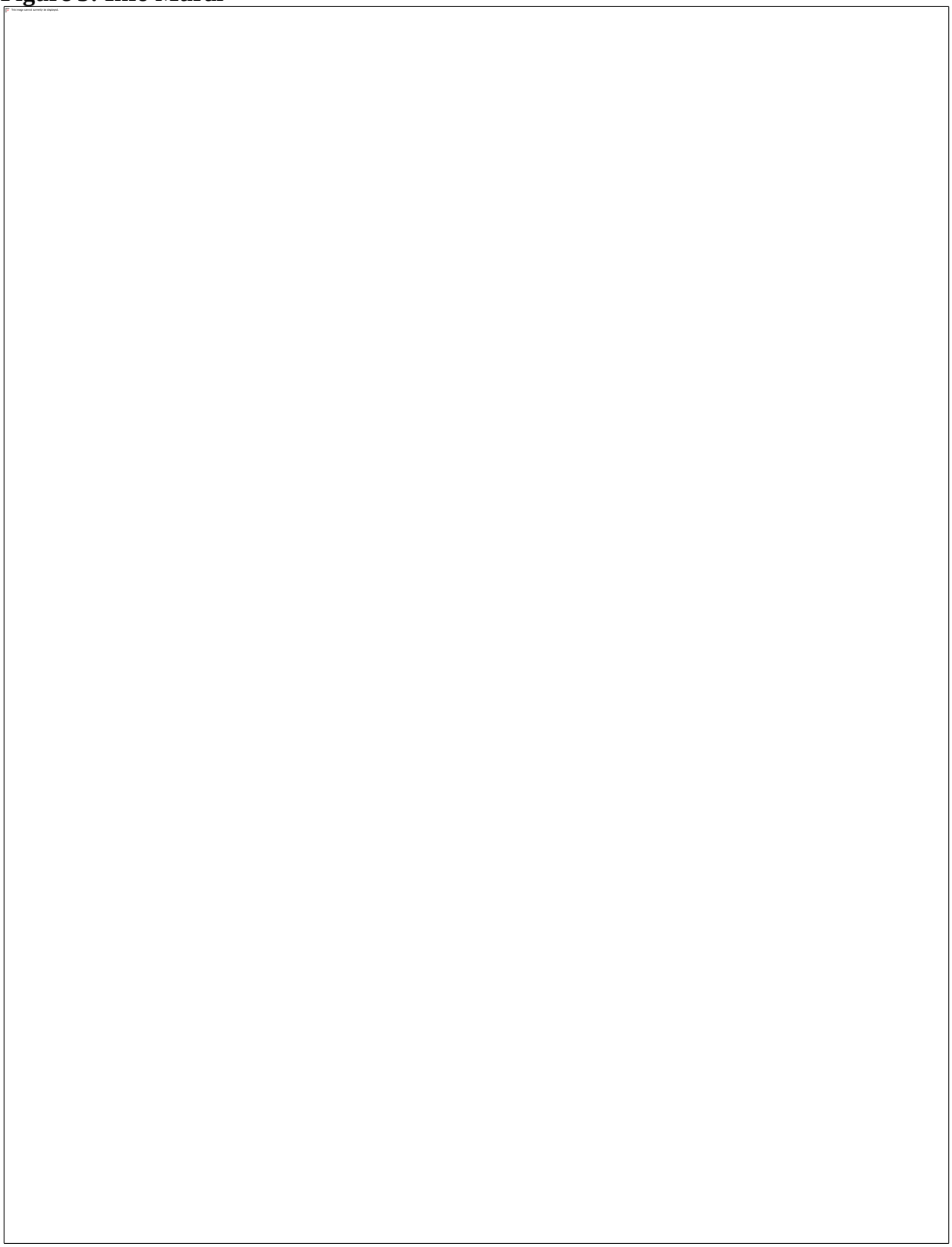
1. Fit comfortably on one page.
2. Be able to be printed at different sizes from a briefcase to large mural size.
3. Be self explanatory (i.e. the reader needs no further information to understand it).
4. Use as much non-technical language as possible.
5. Provide the reasoning of the project in compact form.
6. Encompass the complexity of dealing with the entire resource base of the EU as well as recommended policies.

4.8 Visual design decisions

The "bubbles" organize the five major constellations of concepts: aspirations, constraints, environmental targets, economic targets, and policies.

The arrows linking these five big bubbles guide the reader's eye and thought from top to bottom. The words on the arrows form a kind of segmented verbal-visual sentence, pulling all the major ideas together.
Some readers may have anticipated more visual, iconic elements (e.g. little pictures of forests, farms, factories, etc) that sometimes appear in visualizations like this. Because of the considerable complexity of each of the individual large bubbles, it was decided that additional icons would not perform their normal function of guiding navigation of the visualization, but would instead clutter the visualization making it harder to navigate. Therefore, this visual design option was not used, illustrating that in making design decisions, what not to put onto the visualization is as important a decision as what is required to be on it.

Figure 3: Info Mural



5 An Example Vision for a Resource Efficient Economy

5.1 Introduction

This chapter provides an example of a vision for a Europe characterised by less resource use, respect of planetary boundaries and high quality of life: A Europe in which people enjoy quality education, good health, the option to take part in community networks, and the ability to develop personally, and in which production and consumption are fair and sustainable. The vision is focussed on Europe, as embedded in the world: it considers changes in Europe in the context of global issues, trends, and challenges.

Deliverable 2.1 of the POLFREE project (Report about Synthesis of New Concepts) analyses various views governing system innovations using four archetypical "belief systems" based on cultural theory. Using this heuristic, it is clear that **the vision presented in this chapter is based on an "egalitarian perspective"**. As Del. 2.1 points out, an egalitarian society is characterized by operating in social groups without excessively binding rules.

This vision was developed by members of the POLFREE team. It is based on a screening of other visions (see Chapter 2). In a participatory workshop, elements of other visions were clustered to create one vision to use as an example in the POLFREE project. A vision describes a "world that we want": it is not a scenario (a plausible picture of the future). The aim is to describe a future state and then explore through backcasting (see POLFREE Deliverable 3.5) and modelling how this vision could be achieved.

Figure 4 shows the three main elements of this vision: safe and fair use of global resources; a sustainable society and a transformed economy. These elements are described in the following sections (Sections 3-5) from the perspective of 2050. That is, the vision describes what the resource efficient economy in 2050 looks like. The description of how this vision was achieved is covered in Deliverable 3.5 of the POLFREE project, although some elements of "how this vision was achieved" are included here in order to illustrate the very different kind of world that exists in 2050.

As outlined in the introduction to this report, the Description of Work of the POLFREE project outlined several dimensions of the vision that are covered here. The issue of scale is addressed under the consideration of a safe operating space (Section 3). The time dimension of development of radically new technologies and institutions with higher long-term benefits for the year 2050 and beyond is addressed implicitly, since many of the innovations discussed in the vision will also reduce resource use beyond 2050. Property rights are addressed explicitly in section 15. New patterns of sustainable consumption and production and the empowerment that they bring are an underlying theme of the vision. And finally, this vision reflects many aspects of the "beyond growth society" with its emphasis on well-being and new measures of progress.

5.2 Respecting Planetary Boundaries

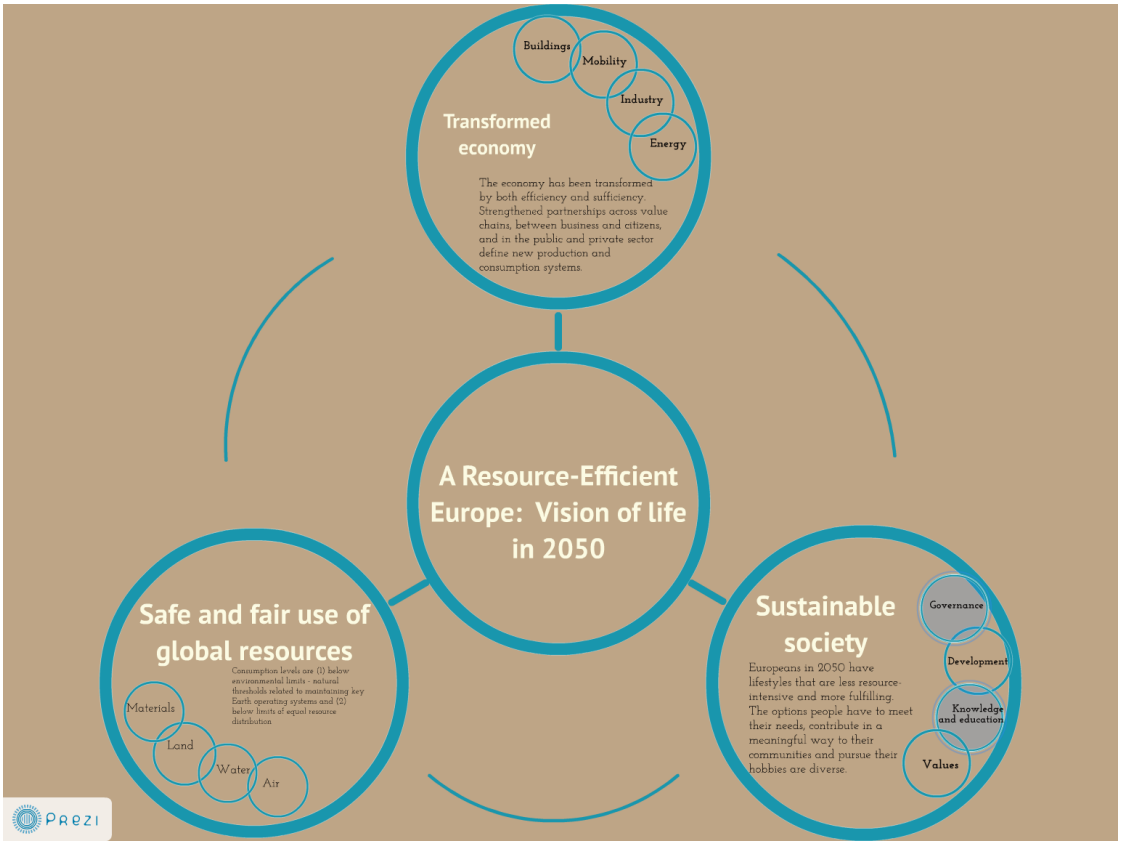
A guiding principle of the vision is that planetary boundaries are respected. Rockström *et al.* (2009)[136] showed clearly that since the Industrial Revolution human actions have become the

[136] Rockström, J., Steffen, W., Noone *et al*. (2009). Planetary boundaries: exploring the safe operating space for humanity. *Ecology and Society* 14, 32. http://www.ecologyandsociety.org/vol14/iss32/art32/

main driver of global environmental change. They also pointed out that once human activity has passed certain thresholds or tipping points, defined as "planetary boundaries", there is a risk of "irreversible and abrupt environmental change". Seven so-called planetary boundaries were quantified. Two additional planetary boundaries (chemical pollution and atmospheric aerosol loading) were identified but not yet quantified.

Remaining within these planetary boundaries in 2050 has major implications for resource use. For example, use of fossil fuels has to be lower than in 2010 to stay within the climate change and ocean acidification boundaries; similarly, use of land and water have to stay below the respective boundaries.

Figure 4: Main elements of the vision



5.3 A Safe and Fair Use of Global Resources in 2050

European consumption of global resources is both within the safe operating space of planetary boundaries and fair. This means that consumption levels are (1) below environmental limits (see Section 2) and (2) below limits of equal resource distribution—per capita use of global resources is below or equal to per capita world availability. A consensus on what constitutes a "safe space" for resource consumption is based on a multi-stakeholder (in particular, policy makers, business, NGOs, and indigenous peoples) agreement based on best available

scientific evidence on tipping points. This safe space has been reached by higher resource efficiency on the one hand and less consuming lifestyles on the other.

Extraction and production practices on the ground are more sustainable—for example, with better maintenance of soil fertility in agriculture, preferred exploration of ´low-burden´ mines and better remediation after mining, and widespread implementation of reduced impact logging in forestry. To this end, certification and transparency are vital policy instruments.

Overall, resource efficiency is improved across the life-cycle of resource use with a multitude of benefits for nature and for people. In particular, it contributes to:

- reducing pressure on natural systems related to both the scale of resource demand and the externalities of production and consumption, and
- enabling greater access to resources for all people to strengthen resource justice across the world.

The following four subsections look at the situation in general for materials, energy, land and water.

5.4 Materials

The EU continues to be largely dependent on imports of metals, but the scale of imports has been reduced as a result of closed-loop design and the development of circular-economy networks for redefining supply chains. As a net-importer of abiotic resources, the EU engages in knowledge sharing and capacity building abroad, in particular to support the integration of mining into development policies in a holistic way at local and regional levels.

Mining is characterized by high levels of transparency and accountability, dedication to worker safety, and reduced environmental impacts. Tools like the Resource Governance Index[137] continue to monitor the quality of governance in oil, gas and mining sectors, but there is no longer a major gap between countries—all countries have achieved satisfactory levels of good governance. Deemed a “common good” the harvesting of sand from the ocean floor is subject to international regulation, and the disappearance of islands, particularly in Southeast Asia, has been halted. Increased urban mining has found new and resource efficient ways to recycle the materials stocked in buildings and infrastructures. These "mines of the future" comprise metals such as steel and copper, wood, plastics, and in particular concrete. Recycling of concrete (including upcycling) also contributes to lowering Europe’s demand for minerals like sand.

Materials are managed so that they do not become waste. Thus, waste generation and incineration are reduced to an absolute minimum. Effective systems of material stewardship and global extended producer responsibility support the production and use of resource-light products. Product-service-systems are very common. Information and Communication Technology devices and infrastructures have played a role as persuasive technologies - leading to massive increases in resource-efficiency of consumption patterns – and no longer rely on critical raw materials. These technologies are designed to be durable, repairable and in the end recyclable. Illegal shipments of waste have been eradicated. Energy recovery is

[137] http://www.revenuewatch.org/rgi

limited to non-recyclable materials, landfilling of organic materials is eliminated and deposition of minerals kept to a minimum, while high quality recycling is ensured.

The eco-efficiency of materials has on average improved by a factor of 10. Advanced materials enable resource hyper-efficiency in key sectors, such as transport and energy.

5.5 Energy

In 2050 Europe has an energy system that is low-carbon, resource-efficient, secure and competitive. Energy supply in 2050 is provided through a low-carbon energy system (emissions of CO_2 have been reduced by 80% compared to 1990) that is based on a mix of predominantly renewables supplemented where necessary by natural gas. Primary energy demand is around 40% lower in 2050 than in 2005. There is a very high share of renewable energy supply in electricity consumption. Electricity plays an important role in satisfying final energy demand and in particular energy demand for passenger cars and light-duty vehicles.

The average capital costs of the energy system are high due to investments in power plants and grids, in industrial energy equipment, heating and cooling systems (including district heating and cooling), smart meters, insulation material, more efficient and low carbon vehicles, devices for exploiting local renewable energy sources (solar heat and photovoltaic), durable energy consuming goods etc. At the same time, decarbonization of the economy means that fossil fuel import dependency has been reduced considerably.

Decentralisation of the power system and heat generation is higher due to more renewable generation. Centralized large-scale systems and decentralised systems work together and depend on each other. Access to modern energy technologies is universal. This means that there is energy interdependency of small groups, communities and cities as well as multiple benefits for society (energy security, decreased poverty, increased welfare and health) with a more resilient energy infrastructure.

5.6 Land

The global expansion of cropland, pastures, and fast-growing tree plantations into grasslands, savannahs and forests was halted in 2020. This means that "land take"[138] in the EU was stopped--especially due to improved city planning--and deforestation, in particular in the tropics, was reversed, also as a consequence of reducing demand of agricultural products so that they can be produced within the global safe operating space. The EU has met both its target initiatives for no net loss of biodiversity and for reducing its level of global cropland use to sustainable levels.

5.7 Agriculture

Transformed food systems have encompassed changes in both production and consumption practices. On the production side, land production systems are diverse and, as a whole, able to cope with climate change. Best management practices integrate scientific and local knowledge on both small and large-scale farms, and there is no longer a significant yield gap between "developing" and "industrialized" countries. Widespread application of the

[138] Land take refers to the expansion of built-up areas (roads, buildings, etc) at the expense of fertile agricultural land.

principles of agro-ecology enhance soil fertility, nutrient cycling and water cycling in both conventional and organic farming systems, and the use of fertilizers, pesticides and water are reduced overall. Practices like "4 R Nutrient Stewardship"[139] are common, representing cases where universal principles have been adapted to local conditions and applied by farmers in knowledge-based networks. Major investments in soil restoration worldwide has enabled cropland to expanded somewhat, into previously abandoned farmland, and food losses from the field to the fork are dramatically lower. Livestock production is more climate-friendly in 2050, mostly due to a reduction in the demand for meat in the EU, enabling a combination of grassland-based production systems and sustainable intensification (especially in the tropics).

EU policies take into account their direct and indirect impact on land and water use in the EU and globally, and there is no net land take by 2050; soil erosion is reduced and the soil organic matter increased, with remedial work on contaminated sites completed.

In the EU, demand for food is oriented toward regional, organic, vegetarian and seasonal foods. This change in diets is supported by programmes in schools aimed at reconnecting children to the origins of their food and reinforced by the many urban gardens spread across European cities. New governance structures now encourage the use of locally-produced foods (especially produce) in schools, hospitals and canteens, as well as at catered events. Diets have shifted toward levels consistent with dietary recommendations, easing pressure on land, lowering the costs of health care systems, and improving human health. Avoidable food waste at household and retail levels has been nearly eliminated.

The EU follows the principle of "food first" for using global cropland. While biomass does contribute to energy supply, this biomass is mainly sourced from residues (after accounting for soil fertility needs) and organic waste. The import of energy crops or derived biofuels is very low and has been nearly abandoned.

5.8 Forestry

Forests in the EU are valued for the multiple services they provide, including the production of timber, provision of habitat, sequestration of carbon, protection from erosion, and connection to cultural identity. Along these lines, forests are under "multiple-purpose management". The import of illegally-harvested timber from abroad has been stopped and the reliance on fast-growing timber plantations abroad, especially in the tropics, has been reduced.

The forest industry in the EU is characterized by its dedication to optimizing "cascades", which means first producing the most value-added from virgin timber, optimizing reuse and recycling, and only using the raw material for energy at the end of its life-cycle. As such, timber is an integral part of the renewable energy mix, in a way that optimizes efficiency. Paper recycling rates are very high[140] in the EU. Consumer preferences are for more durable and long-lasting products (housing, furniture, etc.). The demand for virgin timber is balanced with the harvest capacities of forests under sustainable conditions.

[139] A framework for applying the right nutrient source, at the right rate, right time and right place (http://www.oecd.org/tad/sustainable-agriculture/44795458.pdf).

[140] In accordance with the paper industry's vision of an optimal paper recycling system characterized by a mix of virgin and recycled fibres (CEPI 2011).

5.9 Water

The quality of Europe's inland and coastal waters in 2050 is high. Water scarcity in Europe is reduced through highly efficient irrigation systems, closed loop water use systems and increased use of rain-fed crops. Most significant is the full implementation of integrated resource (water and land) governance and management at the water basin level. Water is not seen as a product from which money can be made, but as a central element of human well-being that must be protected in addition it must sustain terrestrial and aquatic ecosystems and the multiple functions, goods and services that they provide. All people in Europe but also worldwide have access to clean water and sanitation. Ocean acidification has been halted and pollution of the oceans (waste, oil, plastics etc.) is drastically reduced.

5.10 A Resource-Efficient Economy

In a resource-efficient economy citizens and public authorities have the right incentives to choose the most resource efficient products and services, through appropriate price signals and clear environmental information. Morover, purchasing choices stimulate companies to innovate and to supply more resource efficient goods and services.

In general, as an overarching goal in the economy, labour and trade are to contribute to human and natural well-being. Strengthened partnerships between businesses (along their value chains), between business and citizens (leading to much greater levels of user-led innovation) and business and governance (to get the framework conditions for "eco-innovation" right) characterize the new production and consumption systems. On the production side, resource requirements across the economy have been lowered—with the development of new materials, technologies and processes for efficient manufacturing and remanufacturing. New business models offer services to meet customer needs in resource-efficient ways. Citizens have embraced change and not only adapted their living, mobility and consumption behaviours, but were also important agents in shaping these changes. This implies not only partnerhsips between business and policy and business and citizens but also multi-lateral partnerships.

The new economic order is not only characterized by the reduction in the amount of natural resources used in goods that the European economy produces but also by the way goods are produced. Industry internalizes the true external production costs in product prices and the EU policy framework provides incentives for long-term investments, new business models and industrial symbiosis. Business has dramatically increased its resource productivity. Since there is a monetary value on ecosystem services used by business, government, and other organizations, the use of these services is included in planning, accounting and operations. This contributes significantly to maintaining a resource efficient economy.

5.11 Labour, Industry and Technology

A working time reduction allows more free time for caring for the elderly or working for the community and also contributes to lowering resource use.

The manufacturing industry has been transformed to respect the limits of non-renewable resources. End products are more efficient, last longer and use less material. Closed-loop production patterns are used in all economic sectors - reducing the need for primary resource extraction and making the concept of waste obsolete. Industrial symbiosis is normal business practice and all European companies have internalized the circular approach to resources.

Used products and materials are reengineered to function again for multiple and distinct purposes or reduced to raw materials for manufacturing other products. The chemical industry has switched from fossil resources to renewable input materials used at a sustainable level for the production of plastics, polymers and other products. Bio-refinery allows for the sustainable processing of biomass into a spectrum of bio-based products (food, feed, chemicals, materials) and bioenergy (biofuels, power and/or heat). The backbone of carbon supply for durable products (made of polymers) is provided by recycling, including capturing CO_2 from waste incineration as raw material for the production of platform chemicals.

In 2050 the leading companies are those that, through their core businesses, help society manage the world's major challenges. Multitudes of new small and medium-sized businesses support the resource-efficient economy. As in the society, also diversity among enterprises has grown drastically, as Europeans increasingly realize that diverse systems are more resilient. In 2050 all European companies value cooperation, transparency and mutual learning rather than fierce competition. The substitution of services for products is an increasingly popular business model. Dematerialization and service-based consumption have become a major trend in the European society.

5.12 Housing

The housing and building sector use a significantly lower amount of land, water and energy in 2050. Green buildings are the norm for all public buildings. The construction industry contributes to the resource efficient economy through renovation and refurbishment, increasingly sourcing recycled materials from urban mining, and employing ever-increasing resource-light innovations in (re)construction. This contributes to a steady-stocks society, as the net addition to stocks approaches values of around zero, and the industrial metabolism is no longer characterized by the linear flow of resource extraction to disposal, but rather on greater cycling within the economy. Additionally, modular construction enabling easier repair, rebuilding and rearranging of the building and greater technology integration, especially building-integrated photovoltaics (BIPV), are common. Through a systemic planning approach, new buildings are built by combining the high technology aspects of sustainability - smart grids and efficient heating and cooling - with the natural advantages of earthen walls, rooftop gardens, and indoor vegetation. Resource use is also reduced by the choice of construction materials, sharing of equipment, shared spaces and buildings performing different services during the day and at night.

Overall, the renovation and construction of buildings and infrastructure uses high resource efficiency levels. All new buildings are at least nearly zero-energy and many produce energy (energy-plus houses) and highly material efficient. 100% of non-hazardous construction and demolition waste is recycled.

Resource efficiency is also supported by new ways of living together. The proportion of cohousing is high and elements of this way of living together are also found in more conventional housing cultures. Sharing household chores and responsibilities, jointly organizing cooking and other household activities, coming together for meals, keeping an eye on each other's children and on older or ill people are common practices. The changes in the building and housing sector also changed mobility patterns, especially in the increasing urbanized areas: Small-scale settlement structures and living close to work and amenities

reduced travel demand and the remaining travel is carried out using sustainable alternatives, such as car sharing systems.

5.13 Mobility

Europe has a new understanding of mobility. It is not about travelling a lot and fast, but little and mainly for only short distances.

This means that the transport system is low-carbon, resource-efficient, secure and competitive and uses clean technologies and transformed transport networks. Mobility and transportation in 2050 is accessible and affordable for everyone, but in different ways than in the past. There are still cars, but they are motorized by a mix of electricity, hybrid engines and renewable fuels. The overall effect and the societal meanings of mobility are seen from a new perspective: the importance of being mobile for social inclusion and participation in the social and cultural daily life of poorer, elderly and handicapped individuals is recognized strongly. Accordingly, new infrastructure measures are on the one hand adapted to the demands of all people; and on the other hand are evaluated concerning their long-term effects on the environment.

The daily leisure as well as household-related (e.g. shopping) transportation demand in urban areas and cities is covered mainly by free public transport (which satisfies not only passenger demands, but also covers the whole urban area through e-mobility buses, tramways and ultra-light transport systems[141]) and variable sharing concepts (car & bike sharing schedules and car & van-pooling). Private car driving in cities is virtually zero as a result of many incentives (e.g., people from rural areas can use widely available park- and - ride facilities at the city boundaries). The modal share of biking and walking is high. This has great positive effects on the health and overall quality of life of all inhabitants. People are now aware about the "real costs" of unsustainable transportation for humans and the environment. Accordingly, aviation transport is considerably reduced through taxes and restrictions. Goods and freight transport in cities is now carried out by cargo bikes[142] for small to medium sized goods and by zero-emission lorries and trucks. International and bilateral goods and freight transportation is done mainly by railways and ships (i.e. "green shipping"[143]). The huge share of work-related mobility and commuting is decreased by the expansion of teleworking, the application of new ICT (Information and Communication Technologies) for work and the obligation of having sustainable work-travel-plans as well as mobility plans for each company and business. Business trips are reduced to a minimum by implementing video-conferences and other ICT opportunities.

5.14 A Resource-Efficient Society with High Quality of Life

Europeans in 2050 have lifestyles that are less resource-intensive and more fulfilling. The options people have to meet their needs, contribute in a meaningful way to their communities and spend their leisure time in a resource-efficient way are diverse. Governance plays a key role in creating the conditions, infrastructure and networks which make more sustainable

[141] Cf. http://www.ultraglobalprt.com/

[142] Cf. http://www.christianiabikes.de/; http://www.eltis.org/index.php?id=13&lang1=en&study_id=3015 and http://www.eltis.org/index.php?id=56

[143] Cf. http://www.nachhaltigwirtschaften.net/scripts/basics/eco-world/wirtschaft/basics.prg?a_no=6292 and http://www.greenship.org/

lifestyle choices possible. With greater coherence between local and regional governments and national and EU policies, cities and communities across Europe are meeting the sustainability challenges in different ways. The EU remains culturally diverse--with local architecture, food culture, and traditions a defining aspect of European identity—and has created a common foundation for achieving a resource efficient and sustainable society.

5.15 Values

Recognizing that there is only one planet, Europe aims for convergence in resource use on a planetary scale, while celebrating the diversity of societies and cultures that flourish on the Earth. Through new initiatives in education and awareness-raising, people understand that they are connected to each other and to nature and that humans are dependent on a healthy natural system which has a value on its own. Thus all forms of diversity are important, not only the biological but also cultural diversity and diversity of social and economic systems. Diverse systems are more resilient than others, which is a prerequisite for coping with climate change or possible tipping points that might occur. Europeans respect each other and empower each other to actively lead the life they wish to live.

Human rights are upheld and people have equal access to chances and capabilities. Other leading principles for behaviour are peace, reaching social, cultural and environmental targets and allowing for personal development and flourishing.

Europeans also have learned that living within the boundaries of one planet requires new values in their lifestyles, such as using instead of owning, sharing instead of possessing and appreciating longevity of products. Immaterial consumption has become something to strive for. Property rights and income gaps are limited, which means that the divide between rich and poor is reduced (the ratio of the highest and the lowest income within one institution is 1:7; the property of the richest decile is at most 5 times that of the poorest decile).

5.16 Governance

With a multi-level, polycentric governance system, cooperation rather than competition guides the approaches to dealing with resource efficiency. Long-term, iterative and structured participatory processes lead to increased trust.

Democratically legitimated global governance is strong enough that planetary boundaries, including those for resources, are respected and it provides a framework for regional, national and local participatory approaches towards sustainability. Transparency in governance at all levels is assured. Long-term, systemic (holistic) goals and targets guide short-term decision-making. Monitoring and reporting progress towards goals and targets is carried out at all levels of governance and support adaptive governance, in which learning plays a central role. Minimum environmental performance standards are set to remove the least resource-efficient and most polluting products from the market.

The regional, national and local participatory processes (see also “Open Knowledge Society”) empower citizens and non-governmental organizations to take responsibility in the transition to a resource-efficient economy. At the national level, states have regained sovereignty and play a pro-active role in designing and implementing strategies for resource efficiency, including, for example, green public procurement. Nation states are, however, part of a well-functioning multi-level governance system. Sustainable Resource Management Programmes

have been implemented at the national level, which provide a harmonized approach for pursing decoupling of wealth and resource consumption (taking into account the resource-nexus, i.e. the linkage between different natural resources, materials, energy, water and land) and integrate aims of supply security (food, raw materials, etc.) as well as conservation. These programmes also provide the policy framework which provides incentives for actors in the production and consumption sectors to use their purchases so efficiently that the overall consumption level is within the globally safe operating space. The deepening and broadening of facilitated processes of stakeholder engagement in governance at all levels is based on a new "social contract" that recognizes the joint responsibility of states, business, science, civil society and even individuals for tackling sustainability challenges. A new form of interaction between politics, society, the economy and science brings creativity, resources, capacity, legitimacy and political will together to achieve common goals. The precautionary principle is a fundamental aspect of governance related to resource management.

5.17 Development

In 2050 the world population has stabilized at about 9 (at least 8) billion people. In Europe more than 50% of the population is over 60 years[144]. This requires new forms of health and care systems, pension systems, as well as adapted housing and mobility opportunities. Basic needs (e.g., food, shelter, access to basic education and health care, sanitation and water) can be met all over the world and in addition it is possible to meet the human needs that go beyond the basic ones, such as security, identity, social interactions and freedom. Although there is still a difference between the rich and poor nations, the gap has been reduced. The risk of poverty has been decreased. The rights of indigenous peoples are better protected, especially regarding land tenure and ownership.

Migration out of poverty or because of extreme events has also been reduced due to the fairer distribution of resource access, income and other opportunities as well as through increased support for the developing countries. The migration that still exists is valued, because it enriches the diversity of national societies.

5.18 Open knowledge society

In 2050 Europe has an innovative, open knowledge system, which is based on the fact that there are multiple forms of knowledge and not just scientific knowledge. The general ambition is to protect, promote and whenever possible integrate the diversity of languages, concepts, models and forms of knowledge in ways that support transitions to sustainability. This would include knowledge about solutions to resource efficiency challenges, where an integration of diverse sources of knowledge and open transfer of knowledge could support upscaling of local initiatives. Within this open knowledge system, problems are framed collectively, a plurality of perspectives is celebrated, research is integrative and much more of it is oriented towards the implementation of results, including resource-efficiency solutions, for the benefit of society. The knowledge system deals well with values and with uncertainty through well-designed and -implemented, iterative processes of stakeholder dialogue. These processes foster societally relevant innovation and support effective decision-making at all levels. Learning is essential to adapting to a complex, changing condition and requires learning to learn and learning to co-produce and implement new and prior knowledge in an iterative loop of learning, doing, and reflection.

[144] Cf. http://www.aoa.gov/Aging_Statistics/future_growth/future_growth.aspx

All of this is supported by formal and informal education and capacity building. In a world that is changing, holistic, life-long learning to realize fully the potential that each person has is fundamental for a fulfilled life. Spiritual, cultural and practical abilities, as well as personal and social skills are all part of this learning process. Skills such as integration, communication, collaboration and facilitation /mediation are valued within the research system and academia.

6 Conclusions

This deliverable from Task 2.2 of the POLFREE project documents a whole series of outputs that will be used in subsequent parts of the project. The work started with a review of other visions and some analysis of their characteristics. This review highlighted some important elements for a vision of a resource-efficient economy, showing in particular that the vision must consider not only technological innovations but also social and systemic innovations towards both efficiency and sufficiency. Using these elements a qualitative vision has been produced that illustrates one possible picture of a resource-efficient economy in 2050.

A major effort has been invested in deriving quantitative endpoints for the POLFREE vision. These are based on existing targets, such as those in the EU resource efficiency Roadmap but also targets in other EU documents, as well as in the scientific literature. The targets are ambitious and reflect both the ongoing discussions in Europe but also the vision of a resource-efficient economy. The 8 headline targets that have been derived will be used in subsequent steps of the project. They provide an endpoint for the pathways that will be developed and tested in Work Package 3. The targets provide a basis on which resource-efficiency sub-targets can be defined and they will be used to test the effectiveness of policy mixes.

The visualization of the POLFREE Vision has been discussed in detail at a Stakeholder Workshop held in Brussels in December 2013. The discussions at the workshop were lively and the involvement of representatives from the European Commission, from business and industry, from civil society and the research community provided useful inputs for the development of the vision.

The modelling and synthesis work in subsequent parts of the POLFREE project will provide an opportunity to reflect on the achievability of an ambitious vision for a resource-efficient economy in Europe.

7 ANNEXES

7.1 ANNEX I Participants List Stakeholder Workshop

Europe 2050:
A vision for resource efficiency in a global context

Attendees

Name	Organisation
Alina Neacsu	DG Development and Cooperation
Andrew Scott	Overseas Development Institute
Bob Horn	Macro VU, Inc.
Charles Arden Clark	UNEP
Christine Moeller	DG Climate Action
Elsa Pagnini	EC
Franziska Hartwig	SERI
Helga Vanthournout	McKinsey & Co.
Henning Wilts	Wuppertal Institute
Jakub Wejchert	DG Environment
Jill Jäger	SERI
Karen Arnon	European Parliament
Karin Schanes	SERI
Lie Heymans	DG Enterprise and Industry
Meghan O'Brien	Wuppertal Institute
Michael Warhurst	FOE
Michal Miedzinski	Technopolis Group
Michelle O'Keeffe	UCL ISR
Moritz Kammerlander	SERI
Patrick Mahon	WRAP
Patrick O'Riordan	DG Enterprise and Industry
Paul Ekins	UCL ISR
Peter Borkey	OECD
Rachel Lombardi	International Synergies Ltd.
Raimund Bleischwitz	UCL ISR
Robert Ayres	Emeritus professor

Ruya Perincek	UCL ISR
Silvia Donato	DG Research and Innovation
Simon Johnson	Defra
Sirini Withana	IEEP
Stephen White	DG Environment
Storm Gertjan	Maastricht University
Tom Pegram	UCL Institute of Global Governance
Victor Anderson	Anglia Ruskin University
William Garcia	European Chemical Industry Council
Yvan Faure-Miller	General Commission of Sustainable Development

* Names coloured in green participated at the Stakeholder Workshop.

7.2 ANNEX II: Summary of stakeholder suggestions

POLFREE Stakeholder Workshop 9th Dec. 2013

Stakeholder Suggestions for Europe's Aspirations:

General suggestions for aspirations

- Distributional effects of policy mixes (e.g. fiscal reform) on retaining aspirations have to be taken into account
- Aspirations are not static
- Perhaps it is better to refer to "best practices" rather than aspirations
- Or "best aspirations" (linking to SDGs or human rights)
    - Whose aspirations are these? (a big car can also be the aspiration of many Europeans)
    - "Human security" as a general term to merge 4 related bubbles (healthy food, water & sanitation / education / healthcare for all / security in old age)

- How to relate goals to aspirations?

Specific suggestions for aspirations

Economy

- Increased employment
- Desire for progress (intergenerational)
- Accountability
- Competitiveness is a key issue for EU resource efficiency
- Social economy (more local, community level)
- Level of consumption and lifestyles

Equity on EU and global level

- Equity and Solidarity
- Sense of community
- Aligning individual decisions with wider global impacts/interests
- Less inequality (politically desirable) contradicts with relative income hypothesis (which is also an aspiration) → e.g. status
- Strengthen global interdependence

Stakeholder Suggestions for Constraints:

- Disconnect between aspirations and actions
- Disconnect between individual interests/actions and systemic impact
- Risk and realization of risk of crossing planetary boundaries
- Distributional issues
- Population growth – growing global middle class
- Fish, wood, renewable energy carriers (as additional planetary boundaries)
- Addressing the interrelation between EU land-use change and global land-use change

Stakeholder Suggestions for Targets:
Suggestions for prioritization and clustering of targets

- Divide into emergency targets/ threshold targets
- 4 footprint (materials, water, carbon, land) targets as global headline targets and derive implications for Europe
- Divide targets into sinks (impacts) and stocks.
- One Headline target (e.g. factor 10 reductions)
- Priority targets (e.g. biodiversity, climate, etc.)
- Add economic variable to environmental targets (e.g. productivity/intensity/efficiency)
- Consistency of targets is essential
- Interdependencies (synergies) and trade-offs between targets need to be taken into account
- Develop a sequence of targets. Start from aspirations.

Specific suggestions for wider geographic scope

- Linking global targets to EU targets (since there are important interlinkages and implications for equal distribution)
- Account for distributional impacts. EU policy impact on ROW.
- Agricultural production in EU might help people outside EU to meet needs
- 4 footprint (materials, water, carbon, land) targets as global headline targets and derive implications for Europe

Specific suggestions for targets

- Chemicals
- Acidification
- Air quality
- Nitrogen, phosphorous and nutrients
- Water quality
- Energy efficiency
- Reduce toxics in use and circulation
- Exergy efficiency (by 2013 20% reduction; by 2050 30-35% reduction)
- Increased efficiency automatically refers to decreased emissions

Stakeholder Suggestions for Policy Mixes/Instruments:
A good policy mix requires..

- Take systems approach when developing policy mix. Find synergies in supply chains promoting RE.
- Take into account OECD: flanking policies. Systems approach. Social acceptance.
- Getting business on board (also individually) for coherence in stakeholder processes.
- Fragmentation between public and private sector needs to be resolved. Broader stakeholder process. Integrative policy making.
- One instrument per objective
- Uniform implementation (→ level playing field)
- Aligning interest of society, economy and environment
- Policies should promote the creation of sustainable and well functioning supply chains

Specific suggestions for instruments and policy mixes
Dematerialization

- Phasing out of residual waste

- Policies promoting the substitution of a product with a service
- Labour policies (work force policies) → reduced consumption?

Information

- Policies promoting dissemination of information/best practices (business models)
- Demand side view – education and communication

Finance

- Getting the price of carbon right
- Reform finance sector
- Mobilize financial support for SME innovation
- Reform fiscal policy
    - Fiscal neutrality as a final goal
    - Differentiation between national and local level needs to be taken into account
    - Subsidiarity issue needs to be taken into account

Suggestions for visualization

- Reverse arrows between policies and characteristics.

7.3 ANNEX III: Common Analytical Framework

DRAFT ANALYTICAL FRAMEWORK FOR A VISION FOR A RESOURCE EFFICIENT ECONOMY

1. The need for a Vision for a resource-efficient Europe

In her article on envisioning a sustainable world, Donella Meadows argues from a personal standpoint on why we need visions, if we want this world to become a sustainable one. "Vision is the most vital step in the policy process. If we don't know where we want to go, it makes little difference that we make great progress. Yet vision is not only missing almost entirely from policy discussions; it is missing from our whole culture."(Meadows, 1994)

Improving resource efficiency- the main focus of the Policy Options for a Resource efficient Europe project (POLFREE)- is certainly one of the important strategic goals for the upcoming decade for Europe. It is embedded in Europe's 2020 Vision, Europe's growth perspective for the next decade. However, resource efficiency by itself will not be enough to ensure enduring prosperity, if it does not balance environmental objectives with human well-being. If growth is understood in a sustainable way as a means to enhance our well-being, our 2050 vision needs not only to be environmentally sustainable, but also socially and economically viable. As needs are driving human action, they need to be understood and taken into account when proposing a vision consistent with a higher quality of life for all. Therefore, in POLFREE we are espousing a bold vision for Europe that is grounded in ambition, which will be the basis for further elaboration and exploration in other work packages of the project.

This paper provides the framework to analyse existing visions and develop a draft Vision for a Europe characterised by less resource use and high quality of life of its people: A Europe that contributes to the capabilities for everyone to enjoy quality education, good health, to take part in community networks, to be able to develop personally and in which production and consumption are fair and sustainable. The framework follows two strands of criteria that are relevant for a strong vision:

1. Maintenance of nature and ecosystem functions as the biophysical basis of socio-economic activities.
2. Abilities and adequate conditions for humans to meet their needs and consequently to have a high well-being (together these constitute quality of life).

Such conditions (and pre-conditions) will also refer to structures, institutions, policies and governance.

The Millennium Ecosystem Assessment (MEA) states that life on earth depends on biodiversity, security, basic material for good life, health, good social relations and freedom of choice and action (Millennium Ecosystem Assessment, 2003). For the POLFREE vision, we have adapted the MEA framework to give adequate space to human needs based on Max Neef's approach as it better links human lifestyles (strategies to meet needs) to sustainable development and well-being, including a window for policies.

Our framework hence is structured as follows: the biogeophysical elements and core elements relating to needs (basic human needs and overall health, security, identity, social interaction and freedom).

2. Framework for the POLFREE Vision

The perpetuation of the resource-intensive economic model in Europe and other countries is neither environmentally possible nor can it be sustained economically and socially. The issue of resource consumption and material welfare is therefore inseparably linked to global justice and a fair distribution of global natural resources between all inhabitants of Earth. In the industrialized countries in the medium term a reduction of natural resource consumption by around a factor of 5 first introduced by Ernst Ulrich von Weizsäcker (von Weizsäcker, 2009) to 10 (Schmidt-Bleek, 2009) would be required, in order to provide environmental space for other world regions to increase their material welfare.

Equally, a global vision for sustainable economic development needs to prioritise a high quality of life for all inhabitants of the planet. Quality of life is a combination of objective living conditions and subjective well-being. Objective conditions mean resources and opportunities to meet needs and include, for instance, access to education, medical systems, having a certain income, being given a political voice or being surrounded by a healthy environment. Such objective conditions should include formal institutions in the understanding of, for example, Acemoglu and Robinson (2012) and related policies. The possibility to feel satisfied once attaining these objective conditions is the subjective part within quality of life (Rauschmayer et al., 2011). The most important needs to catalyse human well-being do not necessarily require a high resource input. By putting resource extensive strategies and behavioural patterns into practice and by designing and implementing policy measures, which support such strategies, resource use can be reduced while well-being can increase. The inter-linkage between policies and a flourishing economy has been tested via modelling (MacMod, MaRess etc.). What is new and will be tested in the POLFREE project is the role of resource efficiency in mitigating the demands on nature while improving human well-being.

3. Maintenance of Nature and Ecosystem Functions as the Biophysical Basis of Socio-economic Activities

Humans have shaped the natural environment, developing technological solutions and expanding trade based on the utilization of resources to build an increasingly complex and sophisticated web of production and consumption. They created a standard of living that often surpasses the meeting of basic needs in some parts of the world, whereas in other even resource rich countries people are struggling and sometimes failing to meet their daily requirements.

The human impact on the planet's ecosystem as a whole is now large enough to denote that a new geological epoch has begun: the Anthropocene (Crutzen, 2002). Humanity has become a geophysical force, as influential on earth as other major biogeophysical processes. The scientific literature provides ample evidence, including those related to CO_2 emissions, water use, moving sediments, land-use change, biodiversity loss, river damming and many others related to product and resource consumption (Transatlantic Academy, 2012). Whether directly, through scarcities of specific inputs such as water or indirectly, through social and political opposition, environmental change and degradation, the current situation is presenting new challenges to business-as-usual assumptions about future resource extraction, production, processing and consumption (Lee et al., 2012).

Many of today's most pressing environmental problems, such as climate change, loss of biodiversity and pollution are related to natural resource use. Human economic activity is destroying the very basis of existence. Today, humans extract more material resources than ever before in history. Growth rates in the time period after 2003 were significantly higher than in the 20 years before (3.7 % annually compared to 1.7 % per year before 2003), in particular due to the rise of emerging economies, such as China, India and Brazil. Growth has been observed in all major material categories, but is most pronounced for industrial and construction minerals and metal ores (Dittrich et al., 2012). The high material standard of living which is built on the foundations of high resource consumption and increasing labour productivity - although a significant factor in reducing poverty in some parts of the world, particularly in Asia - is eroding the very basis of the planet. Therefore it is evident that this is not an economic or social paradigm that can or should be replicated in those economies that are still developing. Correspondingly innovative measures need to be found to lift the billion or so people still living in extreme poverty while respecting planetary limits. Rockström and colleagues (2009) estimated to what extent humanity has already crossed the global environmental thresholds with regard to nine specific environmental problems. According to their estimates, humanity has already surpassed three of the nine planetary boundaries (biodiversity loss, climate change and nitrogen cycles) and a fourth (the unsustainable use of phosphorous) has subsequently been found to have been breached (Carpenter and Bennett 2011).

Western lifestyles have become characterized by overproduction and overconsumption that utilise valuable resources while often not contributing to long-term well-being (SERI, 2012). The natural environment in some industrialized countries has improved, for example there has been an increase in forest area and other wooded land in the EU-27 (Eurostat, 2012). This phenomenon can in part be explained by resource decoupling in some industrialised countries, however the burden is often shifted to resource rich developing countries, as embodied in the consumption of manufactured goods in wealthier countries (UNEP, 2011).

The "ecological rucksack" of Western consumption is increasing. Today, an average European consumes between 40 and 55 kg of natural resources each day (Dittrich et al., 2012). If resources that are extracted from nature, but not used in our economic system (such as overburden from mining), are included, then these numbers would increase to around 60 - 80 kg per day. In contrast, an average inhabitant of a poor country in development only uses around 8 - 12 kg per day.

Moreover, the lifestyles of people in developed economies have resulted in an unequal distribution of prosperity on a national as well as a global scale. This is also occurring, and will be exacerbated in the context of a growing global middle class in countries such as China and India, where a change in material consumption and dietary habits increases demand for resources which correspondingly increases competition for already scarce natural resources. , While these challenges are common global challenges, they affect people differently in different regions of the world. The extraction of a resource, its conversion into a commodity, and its ultimate consumption, often occur in different countries, and the benefits as well as the environmental impacts associated with each stage in the life cycle are widely distributed across time and space (UNEP, 2012). The risk, that the knock-on effects of unmitigated climate change, environmental degradation and loss of biodiversity may cause social instability, generate mass movements of human population and ultimately trigger political instability and conflicts over access to water and other increasingly scarce resources, is growing. Such insecurity will be driven not by single, linear changes, but by complex interactions between multiple environmental, social, political and governance factors (Lee et al., 2012).

Therefore, the high level of resource consumption in the industrialized world cannot be delinked from hunger, water shortages and energy insecurity in even the remotest corners of the global South. At the same time, the perspective of some 3 billion new global consumers entering the middle class in the coming years does raise a number of additional questions about the consequences to be expected and the possible ways to manage a global transition to a more sustainable economy that functions within planetary boundaries (Transatlantic Academy, 2012).

It becomes clear that, far more than simply an "over there" problem, the increasingly dire living conditions in the Global South will manifest themselves in new challenges for the industrialized countries, in form of migration, propensity for violence and local conflicts that can escalate to wars of global concern (Transatlantic Academy, 2012)

4 The European impact on the environment

The success of European economic development over the past century was primarily driven by the availability of cheap natural resources, including materials, energy carriers, water, land and the atmosphere, while innovation focussed mainly on increasing labour and capital productivity, without at the same time promoting resource productivity and reducing the environmental impacts of production and consumption. Economic growth has considerably slowed down in Europe and many industrialised countries: it is not only natural resources that are becoming scarcer, work cannot be intensified endlessly, and the realms of what can be commercialised are also reaching their limits (Hinterberger et al., 2012).

Europe is appropriating more than its "fair share" of global resource use, with the reserves of many non-renewable resources located outside of Europe, making it the largest net importer of resources in the world (SERI et al., 2009) as well as being heavily dependent on land from other countries, to the extent that it is the world's most land import-dependent continent with a total of 40% (120 mio hectares) of land consumed by Europe every year sourced from outside of its boundaries (SERI *et al,*, 2013). This is not just an environmental issue, it is also an issue of justice for those whose resources are being commercialized (appropriated) to provide economic gain for others.

In Europe, people's connection to the natural environment has arguably dwindled over time as urbanization has increased. European natural systems, exploited to build the economies, have retreated and play a diminished role in the everyday lives of many Europeans. Equally, the European citizen is not an island unto himself/herself, he/she is a part of the global network of trade and consumption, his/her choices influenced by sophisticated marketing strategies and government policies. Natural resources to fuel the economies are now exported from poorer, resource-rich countries where extraction often undermines development and political stability. EU efforts to decouple domestic resource use have been linked to environmental and societal burdens in other countries. This has been proven for CO_2, emissions, land use, material footprints and ecological rucksacks. In parallel with this there is often a capture of resource revenues or benefits accrued from the exploitation of a resource, which do not always reach the poor. Furthermore, monetary compensation for loss of a resource or man-made solutions to replace ecosystem services lost, such as the damming of a river, can have wider social and environmental implications.

For all those reasons, a new vision that can trigger an alternative development path is urgently needed. The elements we believe should underscore the environmental part of a vision are outlined below.

5. Nature

Healthy and well-functioning natural systems are key to our survival and well-being and for all life on earth. Ever-increasing consumption and production patterns are having significant and potentially long-lasting detrimental impacts on their ability to function, and hence support all life on earth. Therefore, our vision for Europe is to maintain nature's ability to support all life on earth. In order to achieve this, our vision for the environment is to maintain its key elements-biotic and abiotic -as the cornerstones for all of life, in a way in which their biophysical limits are respected and integrated into all facets of human interactions with the environment. This should begin with Europe and then expand to deal with its global impacts. Whilst advocating and implementing resource efficiency strategies supported by reductions in overall consumption are important, they are not the only factors that will help to help realise our 2050 vision. Any response must be integrated with the meeting of fundamental human needs as is discussed in a latter part of this paper.

Abiotic and biotic elements

Abiotic elements, elements that are not derived from living organisms such as sunlight and precipitation, and biotic elements, consisting of living organisms such as trees and bacteria, are essential elements of the biophysical components of our vision. They are intricately connected and are the basis of ecosystems and correspondingly, the basis of our well-being and prosperity (WWF, 2012).

As outlined above, the high material standard of living in Europe is built on the foundations of high resource consumption. Thus human impact on abiotic and biotic elements in the pursuit of meeting these needs through activities such as resource extraction, agriculture and urbanisation, are placing huge stresses on the environment at the local, regional and global scales.

Therefore, it is imperative that all activities and strategies that are developed from our 2050 vision must consider and integrate the role of these elements as well those of water and land which are discussed in the next section.

Water and Land

Water is a renewable resource that serves life-sustaining functions for all living beings on earth. Access to clean water is a human right and provides the basis for the functioning of global agricultural systems safeguarding global food security (FAO, 2010). However, the world is facing a progressive increase of scarcity of water resources (FAO, 2012). Water scarcity is a complex issue, since water availability varies in space and time. Simply stated, water scarcity occurs when

demand for freshwater exceeds supply in a specified domain. Water scarcity is both a relative and dynamic concept, and can occur at any level of supply or demand. Scarcity can be expected to intensify with most forms of economic development, but, if correctly identified, many of its causes can be predicted, avoided or mitigated. The three main dimensions that characterize water scarcity are: a physical lack of water availability to satisfy demand; the level of infrastructure development that controls storage, distribution and access and the institutional capacity to provide the necessary water services (FAO, 2012).

Land can also be considered as a renewable resource. Good quality and availability of land resources are essential preconditions for safeguarding food security (FAO, 2010). However, scarcity issues arise as land that can be used is limited by environmental factors including climate, topography, and soil characteristics. Pressures on land resources are continuously increasing due to population growth, changing consumer habits, particularly in emerging economies, and changing land uses to address market forces and energy needs. An estimated 52% of the land used for agriculture, including grazing land, is already moderately or severely affected by soil degradation. During the past 50 years, forest ecosystems have declined by about 15% while pastures and cultivated land area have increased (FAO, 2010).

6. Well-Being, Quality of Life, Needs and Strategies

Healthy and well-functioning natural systems are key to human survival and well-being. Therefore, any 2050 vision must address two overarching goals; meeting individual needs on the one hand, but within the regenerative capacity of the European and global natural systems on the other hand. These goals are inextricably interlinked. In the following we explain and discuss human needs and their link to well-being and quality of life and how this is linked to natural systems.

Quality of life depends on people’s abilities to satisfy their fundamental human needs as well as on the individual perception of one's own well-being.

These abilities depend on the objective conditions of well-being, which consist among others in access to education and health care, infrastructure, income, security, democratic systems, institutions (norms, values, rules, law), politics, labour, tax system.

The ways that needs are experienced are ultimately individual and subjective and can thus not be judged on an objective basis. Well-being is not only felt with regard to consumption or material and economical wealth (except concerning the fulfilment of individual’s basic needs, such as food, shelter or water), but also with regard to social, personal, physical, emotional and spiritual health.

Quality of life is understood as including an objective part (in the sense of the existence of a frame that provides natural resources and abilities being the basis to choose strategies for economic and ecological survival) and a subjective part (in

the sense of subjective satisfaction about one's life) of well-being and leading a meaningful life. “Its [well-being's] hedonic part reflects the pleasure experienced and is linked to emotional well-being, its eudaimonic part reflects the striving to realize one's personal and social potential” (Rauschmayer et al. 2011, p. 10).

As shown in Table 1 a very useful concept in understanding quality of life is Max-Neef’s matrix of needs and strategies, which is an axiological table classifying on the one hand needs according to the categories of Being, Having, Doing and Interacting and, on the other hand, the axiological categories of Subsistence, Protection, Affection, Understanding, Participation, Idleness, Creation, Identity, Freedom and Transcendence which are the needs (cf. Rauschmayer et al., 2011, p. 5). These needs were identified through empirical testing (on the basis of small-scale workshops in Latin America, Great Britain, Sweden and many other countries). They explain how human development in the sense of increasing well-being can be developed directly from bottom up, meaning by the individuals or protagonists themselves, from their actions, expectations, creativity and critical awareness. These needs are common to all humans and cannot be dictated top down.

In general, human needs have to be understood as an interrelated and interactive system that all humans share; which means that fundamental human needs are the same among all cultures and historical periods. Needs could be satisfied in the frame of three contexts: with regard to oneself, social groups and the environment. What changes among all cultures and historical periods are the importance of certain needs (this differs strongly individually) and the strategies through which the needs are satisfied and experienced (cf. Max-Neef et al. 1991, p. 16ff).

Existential categories Fundamental Human Needs	Being (qualities)	Having (things)	Doing (actions)	Interacting (settings)
SUBSISTENCE	physical and mental health	food, shelter, work	feed, clothes, rest, work	living environment, social setting
PROTECTION	care, adaptability, autonomy	social security, health systems, work	co-operate, plan, take care of, help	social environment, dwelling
AFFECTION	respect, sense of humour, generosity, sensuality	friendships, family, relationships with nature	share, take care of, make love, express emotions	privacy, intimate spaces of togetherness
UNDER-STANDING	critical capacity, curiosity, intuition	literature, teachers, policies, educational	analyse, study, meditate, investigate,	schools, families, universities, communities
PARTICIPATION	receptiveness, dedication, sense of humour	responsibilities, duties, work, rights	cooperate, dissent, express opinions	associations, parties, churches, neighbourhoods
IDLENESS	imagination, tranquillity, spontaneity	games, parties, peace of mind	day-dream, remember, relax, have fun	landscapes, intimate spaces, places to be alone
CREATION	imagination, boldness, inventiveness, curiosity	abilities, skills, work, techniques	invent, build, design, work, compose, interpret	spaces for expression, workshops, audiences
IDENTITY	sense of belonging, self-esteem, consistency	language, religions, work, customs, values, norms	get to know oneself, grow, commit oneself	places one belongs to, everyday settings
FREEDOM	autonomy, passion, self-esteem, open-mindedness	equal rights	dissent, choose, run risks, develop awareness	anywhere
TRANSCENDENCE	inner centeredness, presence	religions, rites	pray, meditate, develop awareness	places for worship

Table 1: Matrix of needs including examples of corresponding strategies in four categories (adapted from Max-Neef et al. 1991, p. 32-33)

Based on the fundamental human needs (left column) and divided into four existential categories (horizontal row) – being, having, doing, interacting – the matrix lists examples of strategies (Max-Neef calls them satisfiers) to meet these needs. The four existential categories are defined as follows:

1) Being (i.e. personal or collective attitudes or qualities);
2) Having (i.e. institutions, norms, mechanisms, things etc.);
3) Doing (i.e. personal or collective actions); and
4) Interacting (i.e. locations, milieus or settings).

These satisfiers explain different forms of strategies to meet certain needs meaning for example that having something is not the only way of satisfying a certain need. Let us take the need for understanding as an example. It can be met by being critical and curious and being able to read and write, but also by having access to an adequate education system. Given this, one has to read, learn, inform herself, which is supported by a setting within schools, families or communities.

The example of mobility illustrates how a strategy can meet different needs and how this is linked to well-being and environmental conditions:

Mobility: driving a car (as strategy) may meet the needs for subsistence (e.g. travel to work), affection (stay in direct contact with friends); participation (e.g. meet friends); idleness (e.g. interacting with landscapes due to leisure time travel); identity (e.g. being self-aware or comfortable, having the habit to drive by car) and freedom (e.g. being autonomous) in a positive way. But simultaneously this strategy may inhibit the satisfaction of other and/or the same needs in a long term perspective, such as: subsistence (e.g. bad health due to harmful environmental effects); affection (e.g. having a bad relationship with nature); protection (e.g. damaging the living space); freedom (e.g. being not really autonomous because of dependence on road and oil service infrastructure etc.).Thus one strategy can on the one hand increase and decrease well-being; the second is often related to negative environmental impacts the strategy has got.

Alternative strategies for mobility instead of driving a car are using public transport, riding a bicycle or walking. Of course the possibilities are different in densely populated or rural areas. The effects of these alternatives as satisfiers of needs are individually different. The effects regarding resource consumption and sustainability respectively are obvious and can be even measured in objective numbers.

As this example shows, the satisfaction of needs becomes embedded within a broader context, including effects from the micro to the macro level as well as on the environment, through the application of Max-Neef's approach of needs and well-being.

As soon as people have clarity concerning their "real" needs and realize the variety of strategies they can apply, they have the freedom of choice within the given conditions. Ideally they take sustainability and low resource consumption into consideration for their choice of strategies.

7 Why human needs are central to a vision for a resource efficient Europe

The whole system of mankind and its environment is an assembly of various individual parts that interact on many levels. The behaviour of individuals striving to fulfil their needs and applying more or less sustainable strategies play a central role in the system.

In the following, 5 core elements or set of needs are described. They can be related to Max-Neef's list (the relation is given in brackets).

Basic human needs and health (subsistence & protection from Table 1)

Basic human needs include on the one hand necessities of all humans, like food, clothes, basic hygienic supply and water, and on the other hand additional essentials like shelter and work (i.e. work rather in the sense of life-task). Nevertheless, although in large parts of the world enough resources are given, still a huge number of people are suffering from hunger or thirst as well as from lack of shelter and (meaningful) work. While a lack of food and water concerns especially humans from developing countries (but also increasingly in industrialized countries), lack of shelter and work are reality for more and more people everywhere on this planet. Moreover in a wider sense basic human needs imply interacting with the living environment (social and natural). If the natural environment is already damaged in such a manner that it no longer provides the opportunities of food production (i.e. in a wider sense than agriculture) and drinking water, human beings as well as other forms of living organisms will no longer be able to survive. The category “health” in general is strongly connected to the basic human needs. Without the satisfaction of physical aspects of life an individual won’t develop a healthy physical condition. This lack of biological life necessity will in turn lead to a bad mental condition of an individual as well as the other way round. Moreover if the environment is in a bad condition the basis for human life is questionable or in worst case no longer possible.

Security (protection & understanding from Table 1)

Security is traditionally a very important need of human development insofar as without feeling protected and safe, an individual won’t be able to build up mental health, an existence, family etc. Deficits in protection & understanding can make life in a group or society very fragile. If institutions, organisations and services like health institutions, banks, waste management, food production etc. would not work efficiently any longer, the trust in politics would be reduced. In current times this category is getting more and more important due to increasing natural and social insecurity. On the one hand there are more natural disasters and climate-based catastrophes (WBCSD Vision 2050, p.3), and on the other hand we experience increasing times of social protests, civil wars (e.g. revolutions in several countries in Middle East) and territorial conflicts due to the lack of resources (water or general resource conflicts between India, Pakistan, China and Japan), inter-state conflicts and problems in international security..

This category also implies further important aspects such as care, solidarity, health and/or safety institutions, cooperation, help, social environment and dwelling (from a more technical aspect).This category also includes support by one's family and closer circle of friends. Basically "Security" can be defined as all issues that support or contribute to one's individual security experience.

Identity (identity & understanding & affection & creation from Table 1)

This category is understood as individuality or as being unique; meaning that each individual should have the abilities and the societal and economic (i.e. surviving) frame conditions for developing an own identity and character. Identity is mainly formed through mutual social interaction with significant others (family, close friends, attachment figures) and generalized others (every other individual in the society). Indeed the influence of a healthy environment on one's life is also very considerable for the capability to develop an own identity, in the sense of raising awareness about the whole system of life, including also the natural environment as frame of basic human life and its conservation. In doing so we develop own habits, norms, values, sexuality and skills (physical and mental), as well as seen in a wider scope also important aspects of our individuality such as language, social rhythms, daily social settings, religion, cultural identity, work, self-perception and awareness.

Nowadays, the category identity is a little bit ambivalent, because on the one hand there is the pressure to adapt to society and do certain consumption patterns, as they are the main pathway to individuality; on the other hand we become more and more synchronised due to consumption (each product is a mass-product, fashion trends etc.), social norms (concerning the understanding what can be judged normal and what not), media (pre-selected information) etc.

Social interaction (affection & understanding & participation & creation from Table 1)

Social interactions are the basis of human civilization and development, because without social exchange, phenomena like language, institutions, organisations, rights, norms, values, monetary means etc. could never have been developed (cf. Berger and Luckmann 1969; Searle 1995). Generally social interactions can be performed on a micro level (interaction between particular individuals), on a meso level (interaction in groups, networks, clubs or associations) and on a macro level (interaction in communities, regions or societies). Social exchange and interaction satisfy important needs like affection (through someone's family and close friends), understanding (by someone's social surrounding), participation (in social life or processes) as well as creation (as spaces of expression and social exchange).

In current times there is a huge revolution regarding the development of new information and communication technologies, which could be ascribed to a general strong demand for communication and social exchange between all humans and cultures. Although these innovations are mainly used by an individual

for his/her own benefit, people are permanently embedded or cross-linked into a huge network of social interactions.

It is also empirically validated that "social" interaction between human beings and their natural environment through other forms of life, in particular animals and plants exist (cf. Scheppach 2009).

Freedoms (idleness & creation & transcendence from Table 1)

Basically "freedom" is a very difficult and diversified category as well as often misunderstood. For this paper the category "freedom" is understood as *being* autonomous, which means in detail that each individual has a freedom of being self-aware, passionate, tolerant, playful (foolish), inner centred,; *having* equal rights, daydreams, imagination, privacy, humour, skills, habits, values, norms, sexuality, language, profession of faith (confession of religion), rites; *doing* inventions, designs, interpretations, pray, mediate, develop, awareness as well as finally *interacting* in spaces of individual expression and places of self-communion.

In current time freedom is often used in connection to freedom of choice concerning consumption (e.g. the more variety of goods, the more freedom of choice for each consumer), the freedom of economy (i.e. free or open market system), the freedom of availability (i.e. each good is available at any time) and the freedom of resource use (e.g. depredation of human and natural resources). Basically it is questionable whether this understanding of freedom really equates to an individual feeling of being free and autonomous. For instance the political freedom is not covered by those.

8 Conclusions

The myriads of decisions taken every day by millions of individuals in choosing their strategies to satisfy their needs have an enormous impact on the levels of consumption of resources. These elements are an important part of a vision for 2050.

A framework for the POLFREE Vision

General Information about the Vision			Nature				Core Elements of Wellbeing and Quality of Life					Brief assessment	
Vision Name	Overall objective & background	Geographic coverage	Biotic Resources	Abiotic Resources	Water	Land	**Basic Human Needs** (Subsistence, protection, health)	**Security** (Internal & External, protection, understanding)	**Identity**	**Social Interaction** (affection, understanding, participation, creation)	**Freedom** (idleness, creation, transcendance)	Alternative future presented?	Short critical assessment.
WBCSD													
The great Transformation													
Our Common Journey													
Planet 2050													
2052, Renders													
WBGU													
Europe 2020													
EU Resource Efficiency Roadmap													
Getting into the right lane													
GEO 5													
Degrowth													
Natural Resources Charter													
African Mining Vision													
NIC Global Trends 2030													
Transatlantic Alliance													
WEF More with less													

Based on the discussions above, it is proposed that the survey of existing visions focus on the elements listed in the table below.

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