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Contributors: Jinxue Hu, Saeed Moghayer and Frederic Reynes

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Resource Economics, Economic impact modelling, Resource efficiency policy, Land use, Water abstraction, Environmental indicators

Definitions and acronyms

Acronyms	Definitions
CGEM	Computational General Equilibrium model
ES	Elasticity of Substitution
ETS	Emission Trading System
IO	Input-Output
RMC	Raw Material Consumption
RoW	Rest of the world
SU	Supply and Use
WEI	Water Exploitation Index

1 Executive summary

The main objective of POLFREE WP3 is to asses the social, economic, and environmental impacts of resource efficiency policies, regulations, and social and behavioural changes based on intrinsic motivation. The main approach is to use an integrated modelling of the three pilars of sustaibility, social, economic, and environmental pillars. The main underlying policy question is that how to reach the following environmental targets of the vision for Europe till 2050 (Jäger, 2014):

- Reduction of CO2 emissions by 80 percent (compared to 1990),
- No net rise of agricultural land use,
- Raw material consumption per capita is reduced to 5 tonnes per capita,
- Water exploitation index is below 20 percent.

Pollit, H., et al. (2010) reviews macroeconomic impact modelling for sustainbale developemnt and tries to answer to the question that whether (and how) the current models are suitable for the the evaluation of targeted scenarios of EU environmental policy for a sutainable economy. The paper argues that the answer to this question depends on the linkages between the three areas of sustainability within the model. It concludes that an efficient modelling approach should ideally include "the strong (two-way) linkages between the economy and the environment, the importance of the long term, the necessity of an integrated approach and the danger of thresholds". The two modelling excecise carried out in POLFREE WP3 try to tackle these shortcomings of the current macro-economic models by first analysing of scenarios for all targets simultaneously mentioning the complex interrelations between them and second by linking these models with a vegetation model LPJmL (PIK).

In this study the Computational General Equlibrium model EXIOMOD is used to assess macroeconomic implications of these policies including impacts on economy-wide resource use, costs, competitiveness, trade, configuration of economic sectors, and the environment. EXIOMOD model is well suited to evaluate the impact of policies related to resource efficiency at the macroeconomic, sector and household levels:

- Environmental extensions allows for measuring the impact of various economic activities on emissions and water, land and resource use.
- The global coverage including trade flows allows for analyzing the impact of various economic activities on the environmental indicators in other countries. This feature is particularly convenient to estimate footprints per country.
- The modular approach allows for separating direct and indirect effects, and in particular rebound effects.

In order to model the resource supply constraint for water and land use, EXIOMOD has been extended by water demand and land use decision via linking to the biophysical model LPJmL. The link between LPJmL and EXIOMOD allows for land constraints, water constraints and crop yields per hectare related to the different RCP scenarios. For that, EXIOMOD was adjusted to accommodate the modeling of endogenous land and water use by the agriculture sectors. Water abstraction from agriculture and other sectors as well as land use for different kinds of crops are totally explained in EXIOMOD. Total water availability and the yields per hectare for irrigated and non-irrigated land depending on the basic natural conditions are input from LPJmL.

The land and water use as a factor input will affect crop production and prices. A short description of the model is presented in Section 2.

The starting point for the impact analysis with EXIOMOD was to use the outcomes of POLFREE scenario framework (Jäger & Schanes, 2014) which defines in addition to the EU targets the cooperation in the other countries of the world and allocates plausible policy mixes (Wilts et al., 2014) to different assumptions on governance (O'Keeffe et al., 2014). The scenario framework consists of policy packages aimed at resource efficiency defined under three alternative plausible, future socio-economic pathways until 2050:

- *Global Cooperation*: In this scenario it is assumed that all the EU specific targets mentioned above also applies to all non-EU countries.. A mix of policy instruments are installed globally that can be characterized as "Everything, but hard market interventions". It does not exclude economic instruments completely, but it does without those which need strong administrative interventions, which may not be accepted worldwide.

- *EU Goes Ahead*: The EU countries meet their targets by a policy mix that is "dominated by economic instruments". The instruments like taxes and subsidies mainly change on the supply side of the economy energy and material inputs and the entire structure of production of the economy. The other non-EU countries only implement some climate policy instruments.

- *Civil Society Leads*: The EU countries meet their targets by "bottom-up" instruments. This means that the societal transition is the results of individual and social behavioural changes based on intrinsic motivation of agents. All other non-EU countries are assumed to act in the same way as scenario "EU Goes Ahead" with a moderate climate policy.

In EXIOMOD, the policy packages are translated into a set of specific quantitative policy measures (e.g. different taxes and subsidies via a change in the tax rates) and autonomous changes (e.g. change in the consumption patterns via a change in the final demand). In the implementation of the scenarios, following Task 3.2, we distinguish between driving forces that are the same for all scenarios (basic conditions such as population development) and those that influence the changes in the scenarios in different ways. This means that the same indicators are dealt with in each scenario, but the scenarios vary in the extent and intensity of policy measures implemented in the simulation setups.

Moreover, the three scenarios have been re-characterized to fit the setup of the models and to allow for a quantitative evaluation of the policy packages introduced above. In the first scenario called "Global Cooperation" there are no complex taxation and cap and trade systems as these instruments are not easily implemented in all countries. In Scenario 2 "EU goes ahead" the taxation and other economic instruments play a central role, and regulation and information instruments are also allowed. This seems to be plausible since here only the EU tries to reach ambitious targets. Scenario 3 "Civil Society Leads" is characterized by bottom up policies targeting the information and education of consumers relying on their intrinsic motivation to save the environment.

In addition, a reference scenario is used as a benchmark for comparison of the impacts of the above three scenarios. The reference scenario is characterized by business-as-usual assumptions concerning environmental policy in the EU countries (CO2 emissons targets for 2020 will be reached) and a status quo for all non-European countries. The main driver for the results of the EXIOMOD reference scenario is the exogenous economic growth trajectory, estimated by amongst others the European Commission (EU reference scenario), CEPII (Fouré et al., 2012; Fouré et al., 2013) and IIASA together with other research institutes (Shared Socioeconomic Pathways). The econometric estimations for the CEPII scenario follow the UN population projections (medium fertility variant) and International Labour Office labour projections.

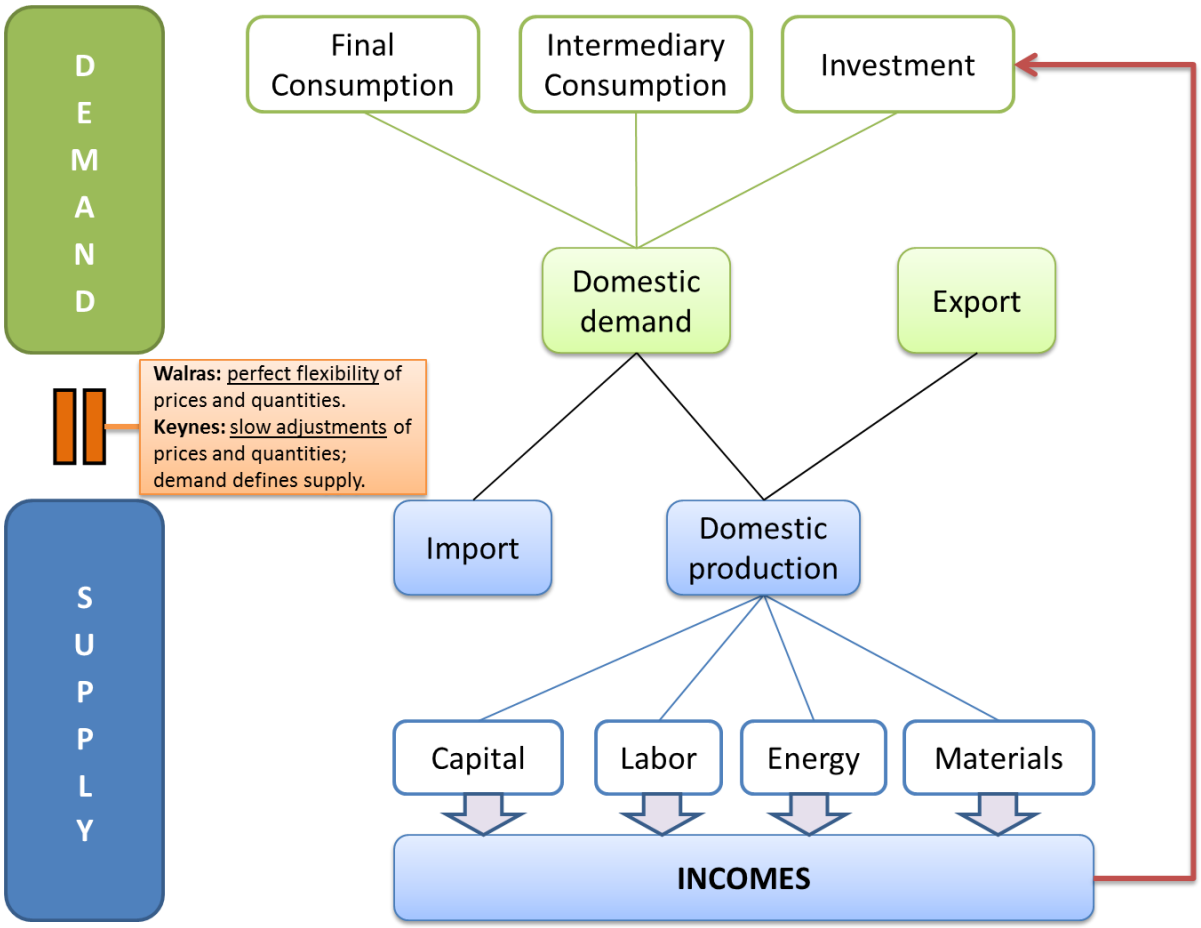
The results of the simulations with EXIOMOD show that the resource efficiency targets are difficult to meet. Additional improvements in resource productivity have to be assumed in order to nearly meet the targets. We also see that Scenario *Global Cooperation* leads to higher environmental performance compared to scenario *EU Goes Ahead*, because all policies are implemented at the global level. In Scenario *EU Goes Ahead* the global effect of the policies are offset by the rest of the world. Scenario *Civil Society Leads* assumes lower economic growth caused by behavioural changes, which leads to a better environmental performance.

2 The model

2.1 Description EXIOMOD 2.0

EXIOMOD is a Computable General Equilibrium Model (CGEM). It therefore takes into account the interaction and feedbacks between supply and demand as schematized in Figure 2.1. Demand (consumption, investment, exports) defines supply (domestic production and imports). Supply defines in return demand through the incomes generated by the production factors (labor, capital, energy, material, land, etc.). In this research, we use a standard Walrasian closure to guaranty the equality between supply and demand: prices and quantities are perfectly flexible and adjust within each time period to clear every market.

Figure 2.1: Architecture of a CGEM



EXIOMOD's name stands for *EXtended Input-Output MODel*. "Extended" refers to the fact that EXIOMOD can extend the standard Input-Output (IO) analysis in two main directions: (1) to CGEM analysis, and (2) to specific topics such as environmental impacts, energy, or transports. Whereas EXIOMOD 1.0 was a standard CGEM with a Walrasian closure, EXIOMOD 2.0 is based on a modular approach specifically designed to conduct both IO analysis and CGEM simulation. With this modular approach and depending on the subject under investigation, the

modeler can easily change the regional and sectorial segmentation as well as the level of complexity regarding the specification of the model by switching on or off specific blocks. In this study, we have switched on blocks that allow substitution between energy and capital-labour as well as differentiated household consumption patterns over time. The rest of the model is kept in its basic form to simplify the interpretation of the results.

The main objective of this modular approach is to overcome several criticisms formulated to standard CGEMs (e.g. see Grassini, 2007; André et al., 2010 for an overview of most common CGEM criticisms). In particular, an important issue for the analyses of results obtained with a multi-sector and/or multi-region CGEM is the abundance of linkages and effects which are difficult to separate from one to another. Because of the general equilibrium framework the direction of causalities is by definition non identifiable. Moreover, the results heavily depend on many assumptions such as the level of elasticity, closing rule, underlying data for the sector disaggregation. To some extent, CGEMs have become too complex to answer specific questions which are paradoxically embedded in them. Typically, whereas CGEMs use IO database, the complexity of their production and consumption structure makes it difficult to isolate IO from CGE effects.

On the contrary, EXIOMOD can distinguish different key effects embodied in CGEM which can greatly help the interpretation of the results. In particular, it can separate volume and price effects. The volume effects are directly derived from the IO analysis whereas price effects come from the general equilibrium framework. Moreover, EXIOMOD can isolate direct and indirect volume effects by distinguishing different type of multipliers (multipliers of intermediaries, of investments and of consumption). In this study, we use the IO analysis to derive raw material consumption indicator (see box in Section 3.1) while the full CGE model is used for estimating the economic and environmental effects of the different scenarios.

The current version of EXIOMOD uses the detailed Multi-regional Environmentally Extended Supply and Use (SU) / Input Output (IO) database EXIOBASE (www.exiobase.eu, Tukker et al., 2009). This database has been developed by harmonizing and increasing the sectorial disaggregation of national SU and IO tables for a large number of countries, estimating emissions and resource extractions by industry, trade linking countries per type of commodities. Moreover, it includes a physical (in addition to the monetary) representation for each material and resource use per sector and country. Using the full potential of this database, EXIOMOD can divide the global economy into 43 countries and five Rest of World regions, and into 163 industry sectors per region. The model includes a representation of 29 types GHG and non-GHG emissions, different types of waste, land use and use of material resources (80 types). For the present study, the model covers 26 regions and 36 sectors/commodities. The list of countries and sectors/commodities is provided in Annex B: List of regions and sectors.

With these features, EXIOMOD is particularly well suited to evaluate the impact of policies related to resource use at the macroeconomic and sector levels:

- Environmental extensions allows for measuring the impact of various economic activities on the use of a large variety of resources.
- The sectorial trade linking allows for analyzing the impact of national consumption pattern on the resource use in other countries. This feature is particularly convenient to confront production based and consumption based indicators of resource footprint per country.
- The modular approach allows for separating direct and indirect effects, and in particular rebound effects. In this study, the direct effect module is useful estimating RMC for each scenario, even if the data (incl IO coefficients) has changed.

The version of EXIOMOD used in this study is characterized by certain key underlying hypotheses summarized below:

- The Elasticities of Substitution (ES) in the current model setup are based on the EPPA model from MIT and could be considered as quite standard (Paltsev et al., 2005). In this study the household consumption patterns are rather important for the scenarios and thus we have used more detailed ES for the household's utility function. All ES values are further described below.
- The production technology is modeled as a nested Constant Elasticity of Substitution (CES) functions. The nesting structure allows for introducing different substitution possibilities between different groups of inputs. Figure 2.2 illustrates the nesting structure used in this study. At the first level, we assume that material is perfectly complementary to the aggregate capital, labor, energy, that is the ES is equal to zero. At the second level, energy can be substituted to the aggregate input capital-labor with an ES equal to 0.4. At the third level, the elasticity of substitution between labor and capital is equal to one (Cobb-Douglas function) and the ES between energy types is equal to 0.5.
- The household's utility is specified as a LES-CES function (Linear Expenditure System - Constant Elasticity of Substitution) allowing to differentiate between necessity and luxury products. This function defines a subsistence level for each good consumed which lead to an elasticity between consumption and revenue lower than one. For instance for food we have a high subsistence level, whereas for other products consumption is more sensitive to the level of income. We assume that the subsistence levels for consumption of products grows at the same rate as population. The subsistence level for energy products is divided by the improvement in energy efficiency. The subsistence levels are based on the GTAP values as used in the study by Lejour et al. (2006). Including all households expenditures, the subsistence level of consumption corresponds to 33 percent of the base year consumption, but this level jumps to 80 percent for agricultural and energy products. Above this minimum level of consumption, substitution between good is possible with an ES equal to one.
- The trade structure is schematized in Figure 2.3. Per type of use (e.g. final, intermediate consumption), a good can either be imported or produced domestically. For simplicity, we assume that the ES is equal to five for each use except for for the following commodities: energy, water, construction (ES = 0.5). This means that energy, water and construction are less flexibile for changing trade partners compared to the other products. In a second step, all imported products per use are aggregated to calculate the total level of imports. In a third level, imports can be supplied by different countries. We assume a CES function the characterized the possibilities of substitutions between regions of origin (with ES = 5). The ES value might seem somewhat high, however it is within the range discussed in the literature (e.g., McDaniel and Balistreri, 2003). Moreover, the high value reflects the observations in the literature that the long-term value of the parameter is relatively high, meaning that trade partners are more flexible in the long-term.
- EXIOMOD related the resource use to the economic activity in several ways. CO2 emissions are directly related to the level of consumption of the energy commodities responsible of the emission. Water consumption of economic activities is related to the level of production. For households, it is related to the water consumption (purchased from the water sector). Materials (such as metal, non-metallic minerals, etc.) are related to the production of the mining sector responsible of the extraction.

- The capital investments per sector are endogenous in the model as shown in Figure 2.2. This means that sectoral shifts (e.g. from non renewable energy to renewable energy) also leads to a change in sectoral capital demand (e.g. non renewable energy requires more capital). The total available stock of capital and labor is assumed as exogenous. In this particular version of the model there is no capital accumulation as a result of investment, leaving development of capital exogenously. The total capital stock effects are based on projections until 2050 on capital and labour stock from the baseline database from CEPII (Fouré et al., 2012; Fouré et al., 2013).
- The "changes in inventories" which are often used to correct for statistical differences are specified as a percentage of final consumption. They are phased out over time by bringing down this share gradually to zero.

Figure 2.2: Production structure in EXIOMOD

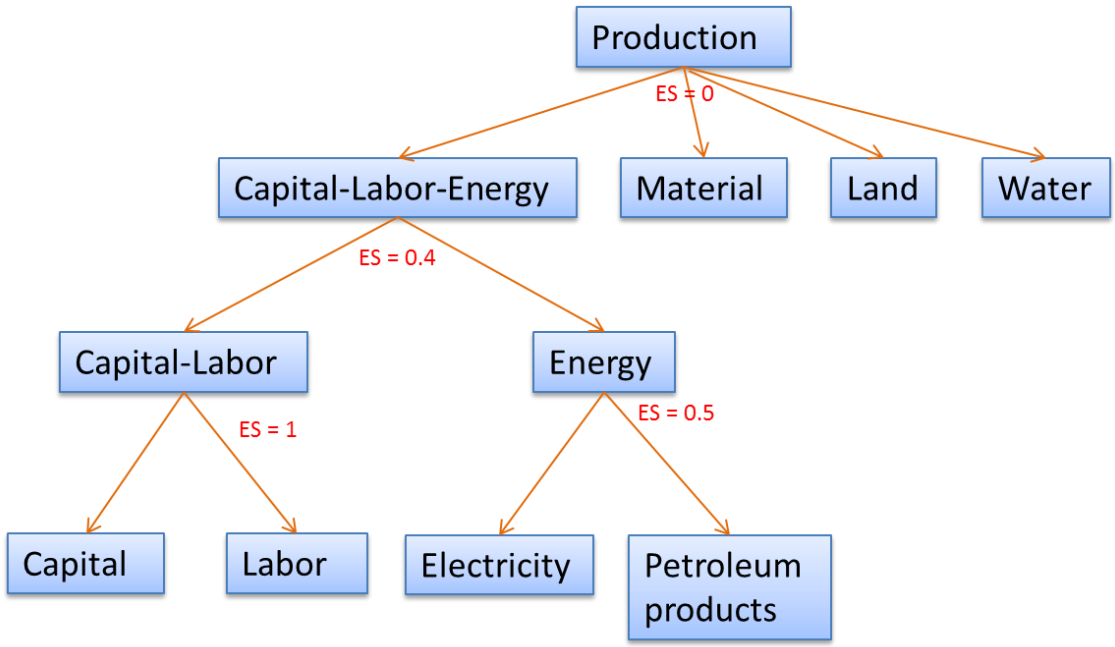
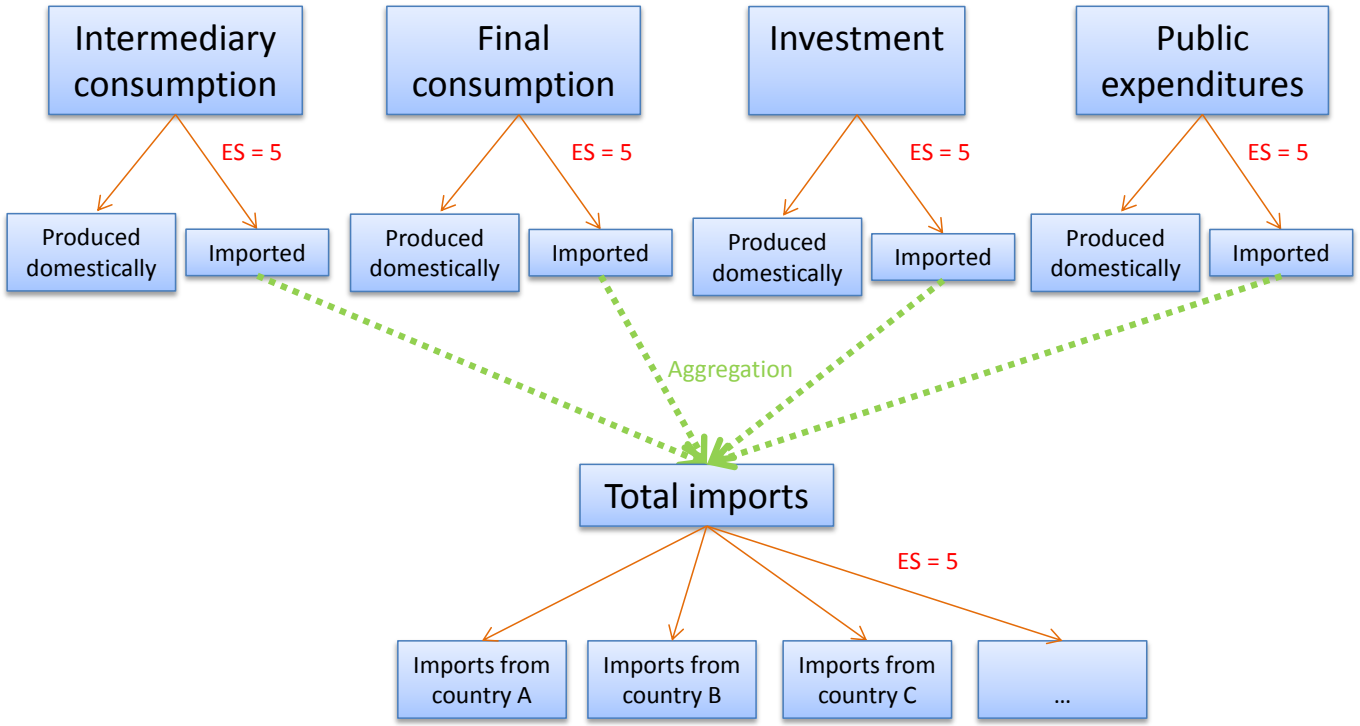


Figure 2.3: Trade structure in EXIOMOD



Note: these ES are set to 0.5 for the following commodities: energy, water, construction.

2.2 Land and water in EXIOMOD

Land and water use are added to EXIOMOD for the purpose of this study. Land and water are treated as production inputs and appear in the production function (see in Figure 2.2) at the same level as materials and capital-labour-energy. A fixed amount of land or water is required for the production of certain products and thus substitution for land or water is not possible. The land productivity does improve over time, which is one of the results from the LPJmL model. This means that over time a lower fixed amount of land is required to produce crops.

In this study we are interested in land use related to crop production. Therefore land is a production input for the crop producing sectors only while water is a production input for all sectors that use water. However water use by sectors in the production function concerns the permanent and temporary use of directly abstracted water. In additional there is also the public water supply which is an economic activity. Public water supply is represented through an endogenous sector and it is supplied to sectors (through intermediate material consumption) as well as households (final consumption).

2.3 Linking EXIOMOD and LPJmL

The EXIOMOD and LPJmL model are linked in order to include planetary boundaries in the economic model. In this study, the planetary boundaries are related to agriculture and are represented by the indicators water availability, yield (or crop productivity) and land availability.

The LPJmL has modeled the first two indicators and differentiated according to the different RCP scenarios. In the reference scenario and Scenario 2 and 3 RCP 4.5 scenario is assumed and in Scenario 1 RCP 2.6 scenario is assumed, following the defined POLFREE scenarios. The third indicator land use is one of the four resource efficiency targets in this study and is therefore separately modeled in the policy scenarios.

The LPJmL crop productivity and water availability are used as an input in EXIOMOD. The crop productivity data showed quite some (seasonal) volatility. This can be problematic for CGE models and we therefore processed it with an average annual growth rate. In addition the data was further processed with the aggregation of LPJmL crop classification to EXIOMOD classification. This resulted in crop productivities that deviate from data from Food and Agriculture Organization of the United Nations (FAO). The global annual average yield increase of 0.48 percent was scaled to 0.67 percent, in order to match the FAO data (Alexandratos and Bruinsma, 2012).

The LPJmL model estimates freshwater availability based on only surface water and not ground water. However, for the calculation of the water exploitation index, we would need both freshwater sources. We therefore assume that the surface water developments are the same as for ground water. Also the water data showed strong volatility over time and is therefore processed with an annual average growth rate.

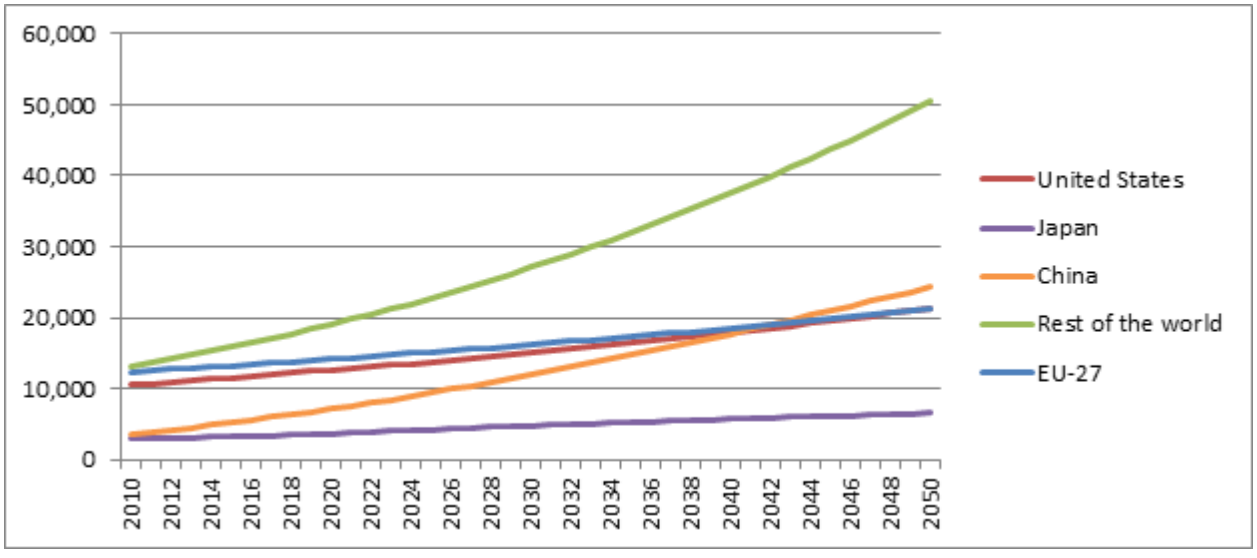
3 Reference scenario

3.1 Assumptions

The main driver for the results of the EXIOMOD reference scenario is the exogenous economic growth trajectory. Such trajectories have been estimated by amongst others the European Commission (EU reference scenario), CEPII (Fouré et al., 2012; Fouré et al., 2013) and IIASA together with other research institutes (Shared Socioeconomic Pathways). We use the scenario as developed by CEPII because it provides more detailed data with larger country coverage. The EU reference scenario provides data for only the EU countries and the Shared Socioeconomic Pathways data were not yet finalized at the time of conducting this study. The econometric estimations for the CEPII scenario follow the UN population projections (medium fertility variant) and International Labour Office labour projections.

The reference scenario is calibrated on the CEPII EconMap v2.2 data (Fouré et al., 2012; Fouré et al., 2013). From this database we use the projections for capital stock, labour supply and trends in capital-labour productivity and energy productivity. The resulting GDP values from EXIOMOD are higher than the GDP values in the CEPII data. This is caused by a different definition of the production function as well as by the price and substitution effects of a CGE model that are not taken into account in the approach used by CEPII. We constrained anyway EXIOMOD to converge the CEPII GDP scenarios by adjusting the capital productivity and capital stock. The GDP projections for the main regions are shown in the graph below.

Figure 3.1: GDP in bln EUR by region in the reference scenario, 2010-2050

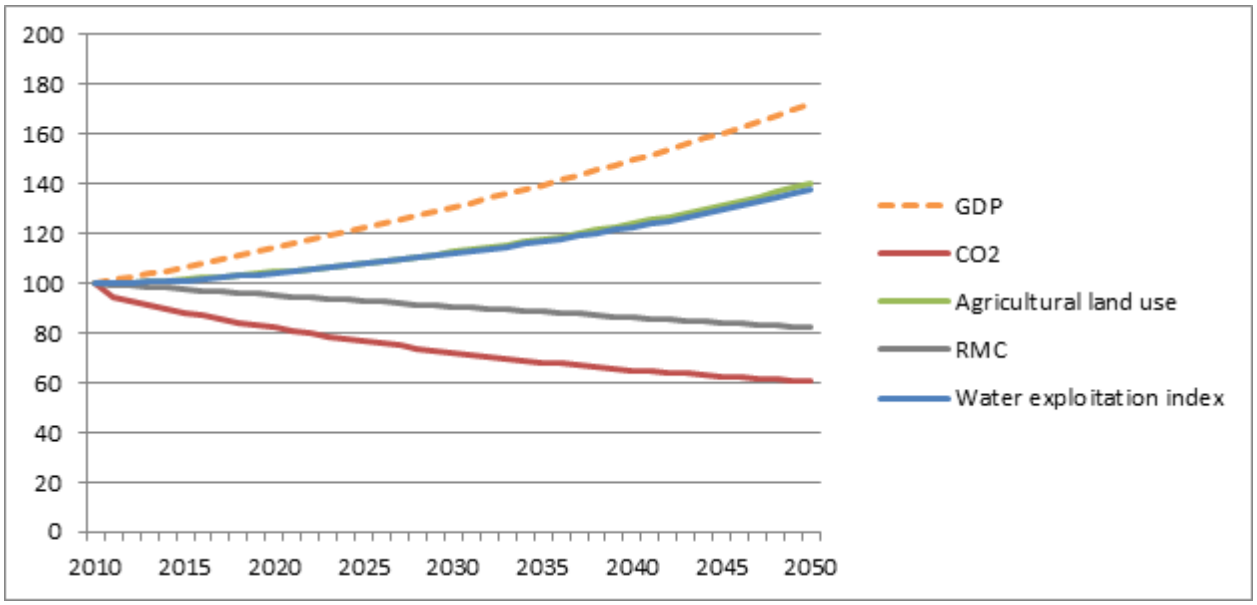


The reference scenario also includes resource efficiency trends for CO2 emissions, material and land use. Land productivity is based on LPJmL data. This data has been aggregated and scaled to an average annual increase of 0.67 percent taken from an FAO study (Alexandratos and Bruinsma, 2012).

The EU reference scenario 2013 anticipates an annual improvement in carbon intensity for final energy demand of 0.5 percent between 2015 and 2050 (European Commission, 2013). We assume the same carbon intensity improvement for the CO2 emission coefficients in our reference scenario. A larger improvement is expected regarding the carbon intensity of the electricity and steam producing sectors. In the EU reference scenario an annual improvement of 3.7 percent is anticipated. On top of the carbon intensity trends, the energy intensity is expected to decrease as well. The EU reference scenario 2013 estimates an annual decrease in energy intensity of one percent for both energy use by sectors and households (European Commission, 2013).

Another study for the European Commission on raw material consumption (RMC) (European Commission, 2014) assumes in their middle estimate scenario a two percent annual increase in material productivity. We apply this assumption on all material use coefficients. These assumptions lead to the following decoupling of resource use in the reference scenario. For RMC and CO2 emissions we even observe absolute decoupling.

Figure 3.2: GDP and resource efficiency indicators in the EU-27, 2010=100



Water exploitation index

The water exploitation index (WEI) indicates the pressure on freshwater resources. This is expressed as the mean annual freshwater demand divided by the long term average freshwater resources. The freshwater demand includes water abstracted from surface and groundwater, both permanently or temporarily. The freshwater demand also includes mine water, drainage water and abstraction from precipitation. The long term average freshwater resources are based on at least 20 years.

The following WEI values indicate the level of water stress of a region. A WEI of 20% is considered a warning threshold for water scarcity.

<10%	non stressed
10-20%	low stressed
20-40%	stressed, severe water stress during drought or low river-flow periods
>40%	severe stress

Source: EEA (2010) and Eurostat (online data code: tsdnr310)

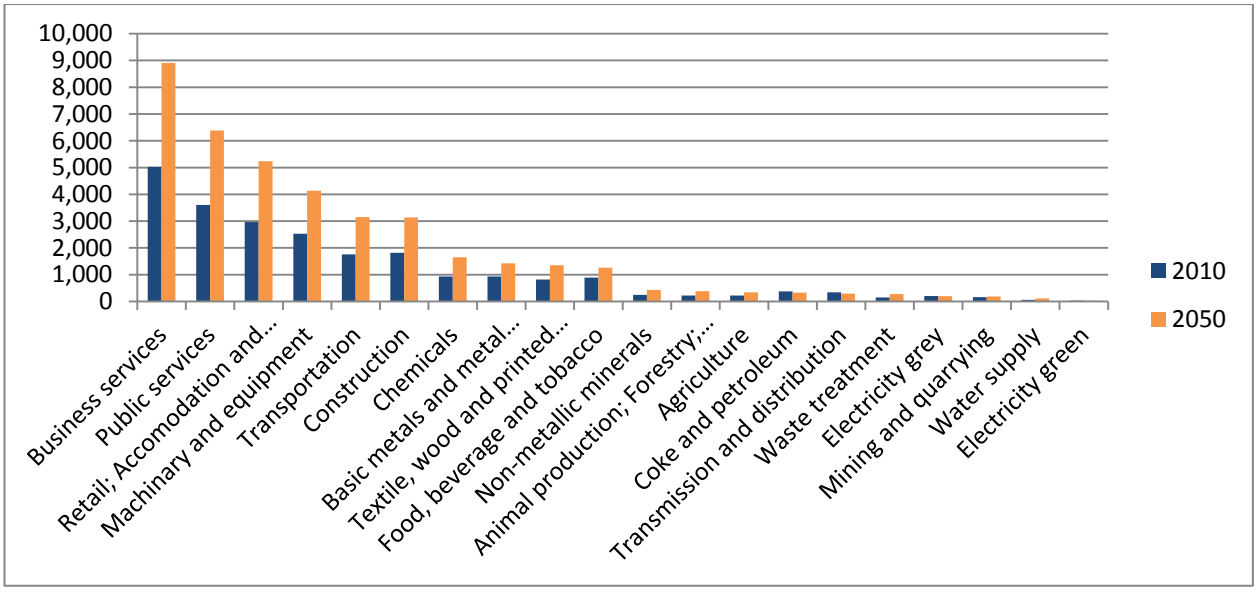
Raw material consumption

The raw material consumption applies to the embodied raw material consumption (RMC) in the final consumption of products. The idea is that material use is extracted in the region of origin, but is meant for the final consumption in the region of destination. To calculate the embodied raw material use, we would need information on the all material inputs to produce a product, as well as all regions of extraction, production and consumption. With an environmentally extended multi-regional input-output table this is possible. We apply the EXIOMOD 2.0 input-output model using the EXIOBASE 2.0 database. The estimated total RMC of the EU in 2010 is 19 tonnes per capita. At the global level the RMC is ten tonnes per capita (which equals the domestic extraction used (DEU) because the region of extraction and consumption are the same).

3.2 Results

3.2.1 Economic and resource efficiency performance

Figure 3.3: Sectoral output in bln EUR in the reference scenario in the EU-27, 2010 and 2050

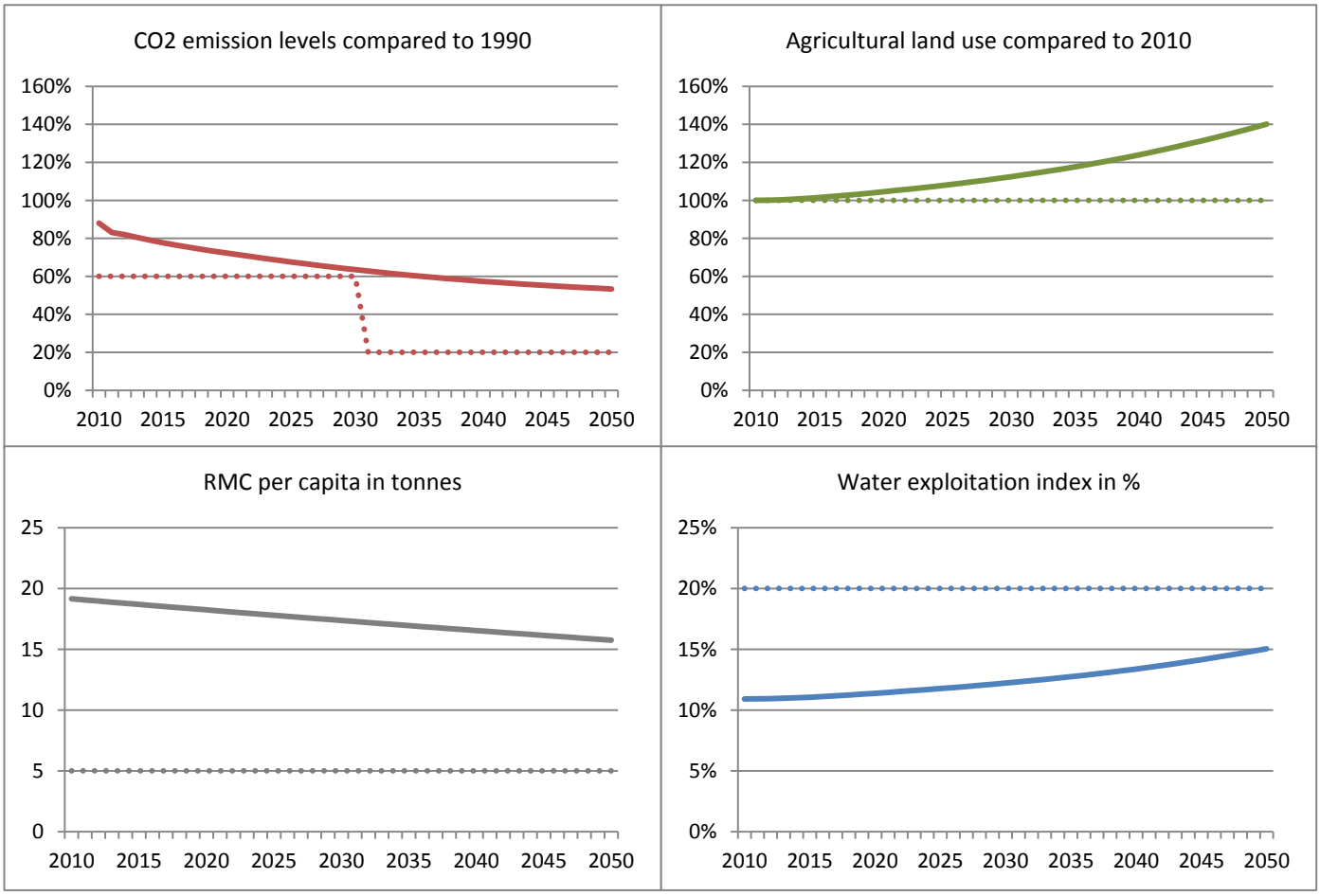


In the reference scenario we can observe that demand for services in the EU grows significantly more by 2050 compared to the primary and secondary sectors. The income is growing gradually over time and additional income is spend relatively more on luxury goods rather than on neccessity goods. The distinction between the preferences for the types of goods is expressed through the income elasticities. Typically services have higher income elasticities compared to for instance food and medicine. We therefore see the trend of increasing demand for services. This trend will have a positive effect on the environmental pressure. Emissions and material use are mostly emitted or used for the production process in primary and secondary sectors.

In this study, the environmental performance of the EU is measured through the four resource efficiency indicators on CO2 emissions, crop-related land use, RMC and water exploitation index (WEI). The CO2 emissions are compared to the 1990 level of 4407 Mt. The 2050 target is

20 percent compared to 1990 (or 80 percent reduction). In the reference scenario by 2050 the CO2 emissions amount to 53 percent compared to 1990. The target for crop related land use is zero net expansion compared to the base year, in our case 2010. In the reference scenario without any land regulation, 40 percent land expansion is required to meet the demand for crops in 2050. However it should be noted that the models (LPJmL and EXIOMOD) do not take into account the closing of the yield gap (less productive farmers catch up and become more productive in the future).The 2050 target for RMC is five tonnes per capita. The WEI increases to 15 percent by 2050 and does not exceed the target level of 20 percent. This means that even without any policy intervention the EU will not become water-stressed at the aggregate level. However, note that at the country level some regions are already water-stressed in the base year, such as Cyprus, Belgium, Spain, Italy and Malta. In the remainder of the section more results are shown on the environmental indicators.

Figure 3.4: Resource efficiency indicators in the reference scenario and 2050 targets (dashed lined) in the EU-27, 2010-2050

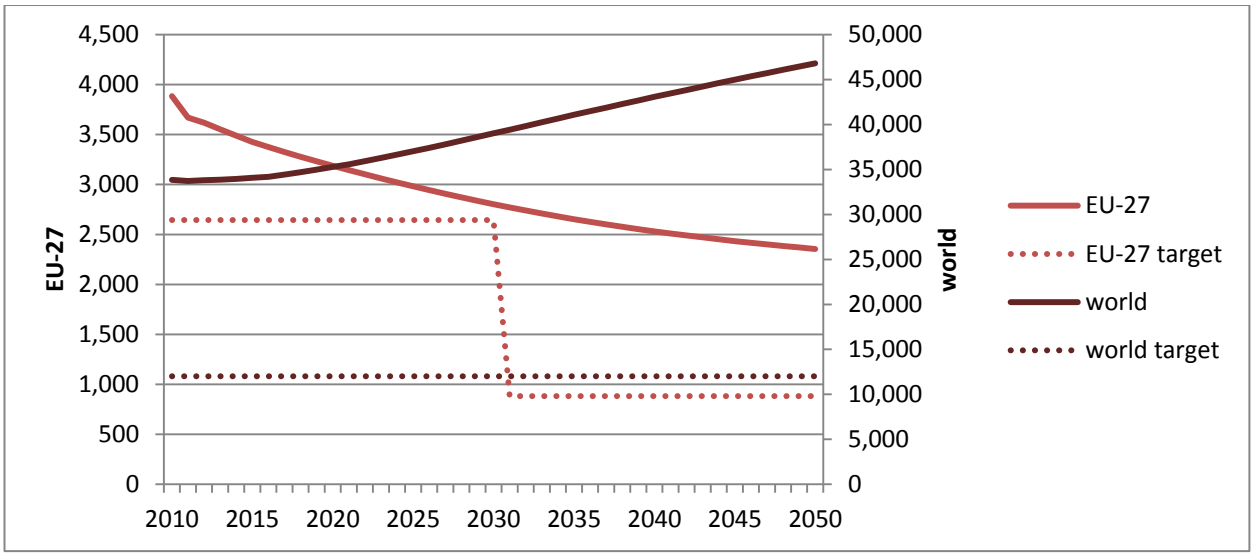


3.2.2 Energy and emissions

CO2 emissions steadily decrease in the EU and reaches its 2030 target of a 60 percent reduction compared to 1990. The 2050 EU target is not met without any additional policy interventions. The world target for CO2 emisisons by 2050 shown in the graph is based on the illustrative two degree pathway used for the Shell LENS scenarios (Royal Dutch Shell, 2013).

The global CO2 emissions increase over time and the gap with the 2050 target is significant. The global CO2 emissions are about four times the target level when no additional interventions are implemented.

Figure 3.5: CO2 emissions in Mt in the reference scenario, 2010-2050



3.2.3 Raw materials

The two graphs below show the RMC for the EU and the world. The RMC per capita in the EU amounts to 19 tonnes in the baseyear and gradually decreases over time. The non-metallic minerals represent the major part of RMC when measured in weight. The fossil fuels show the largest decrease by 2050. This is explained by the uptake of renewable energy technologies and improved energy efficiency. Still the EU is far from its target of five tonnes per capita. At the global level the RMC is 10 tonnes per capita. Especially fossil fuels and non-metallic minerals are lower at the global level compared to the EU.

Figure 3.6: EU-27 raw material consumption in tonnes per capita by material type in the reference scenario, 2010-2050

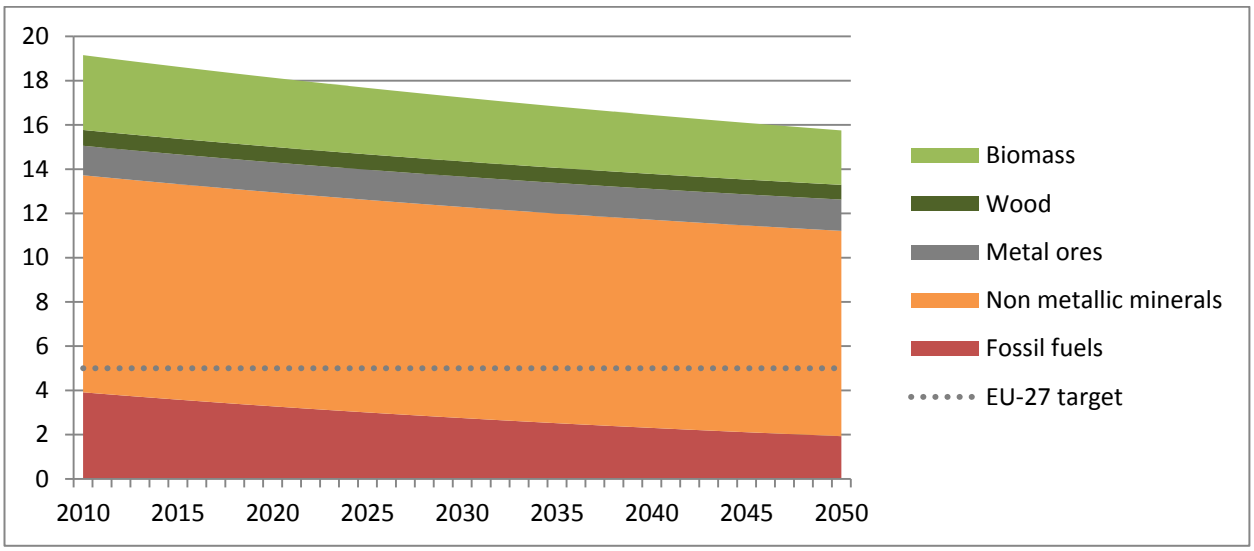
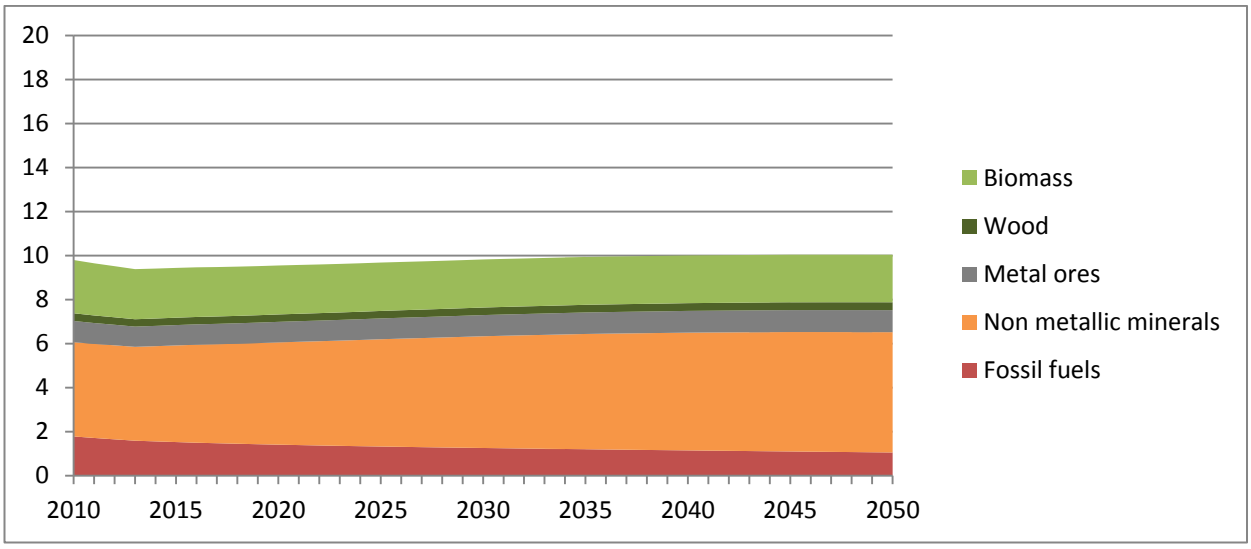


Figure 3.7: World raw material consumption by abiotic material in tonnes per capita in the reference scenario, 2010-2050



Raw materials

Biomass
Biomass consists of crops and animals. These can be used as energy source, biogenic feedstock in products and food.

Wood
Wood is often used for wood products (e.g. furniture), paper products, pulp products and bioenergy.

Metal ores
Metal ores are essential for the production of many types of equipment and (electric) machinery for amongst others transport, medical and consumption purposes.

Non-metallic minerals
Non-metallic mineral resources include salt, sand, fertilizers, stone etc. These are essential for the production of infrastructure as well as for industrial and consumer products.

Fossil fuels
Fossil fuels are mainly used as energy source. The use of fossil fuels for other materials (e.g. plastics) is much smaller.

Source: European Commission (2014) and Eurostat Economy-wide material flow accounts (EW-MFA)

3.2.4 Land and water

The two figures below show the reference trajectory for land use and water abstraction. Both resources are strongly related to agricultural activity. Water is also used for other purposes such as the cooling in electricity production and final consumption by households. We see that land use increases both in the EU and in the world. The largest increase takes place at the world level where land use grows from 1398 mln ha in 2010 to 2882 mln ha in 2050. We see a similar trend in water abstraction. The water abstraction in the EU increases with 56 percent by 2050 whereas the water abstraction in the world increases with 168 percent. However it should be noted that these values can be seen as upper boundaries. The reason for this is that the models (LPJmL and EXIOMOD) do not take into account the closing of the yield gap. The closing of the yield gap means that less productive farmers catch up and become more productive in the future. In the current models setup there is only overall yield improvements for all farmers.

Figure 3.8: Land use for crop production in mln ha in the reference scenario, 2010-2050

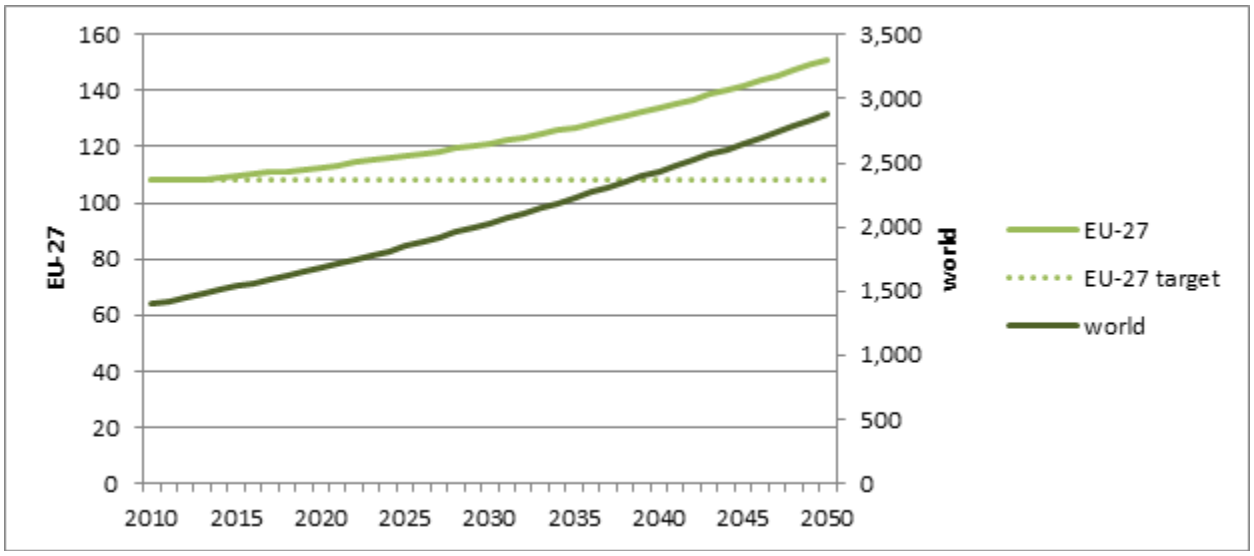
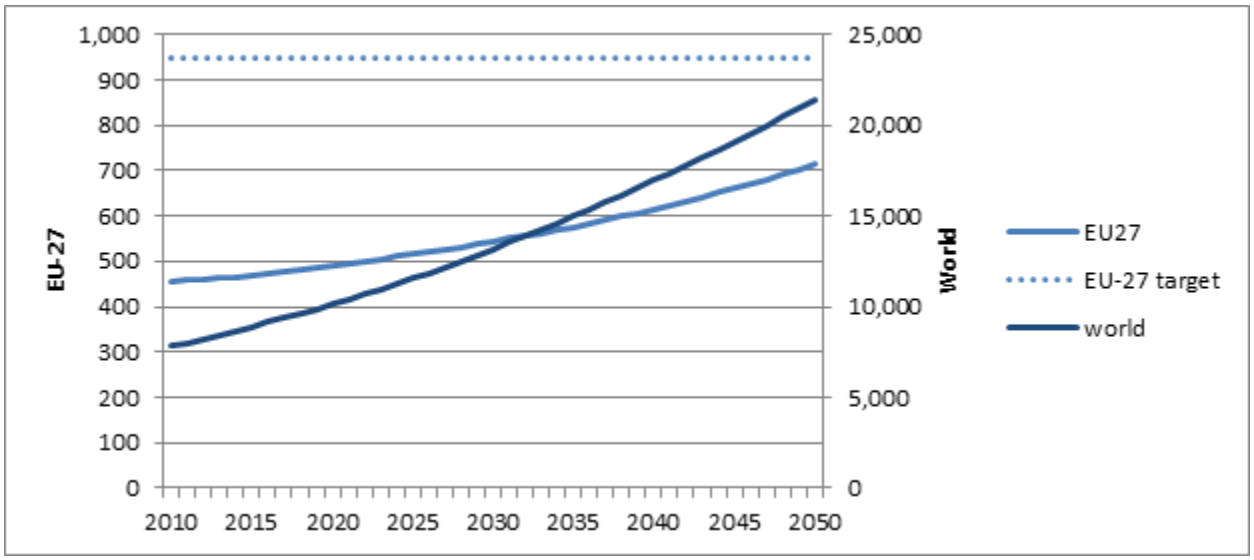


Figure 3.9: Water abstraction in km3 in the reference scenario, 2010-2050



4 Policy scenarios

The three policy scenarios were based on the results from Task 3.2. The objectives, targets and overall vision resulting from this task, were translated into concrete policy packages including assumptions on the quantification of the policy measures. The three scenarios are in the form of policy packages aimed at resource efficiency defined under three alternative plausible, future socio-economic pathways until 2050:

- "Global Cooperation": Globally a mix of instruments is implemented that can be characterized as "Everything, but hard market interventions"
- "EU goes ahead": Only in the EU a mix of market instruments is implemented.
- "Civil Society leads": Only in the EU structural change via intrinsic motivation is happening.

The policy packages include various policy measures aimed at different target groups. Energy related policies include reformed ETS, fossil fuel extraction taxes and quota for renewables. Mobility related policies include carbon standards for cars and stimulation of public transport. For buildings a subsidy should increase the renovation rate to three percent per year. Policies targeted at the industry are metal extraction taxes, recycling quota for metals, non-metallic minerals and paper, RMC (or footprint) based taxes, mandatory eco-design standards, water taxes and innovation funding. Food, agriculture and forests related policies include reduction of food waste, meat taxes and regulation on land and water use.

These policies are implemented in a different configuration for each scenario. The list of policies implemented per scenario can be found in the sections on the scenario and a summary overview is given in Annex A: Implementation of policy measures into EXIOMOD 2.0. In Scenario 1 the policies are implemented at the global level. There are no complex taxation and cap and trade systems as these instruments are not easily implemented in all countries. In Scenario 2 and 3 policy measures are implemented only at the EU level. In Scenario 2 "EU goes ahead" the taxation and other economic instruments play a central role while in Scenario 3 addition autonomous changes are assumed on consumption patterns and working hours, driven by intrinsic motivation.

In all scenarios the environmental tax revenues are fully recycled through a reduction in labour costs. Half of the tax revenues is used as reduction in employer social contributions and the other half is used for the reduction in employee social contributions. In this way we automatically include a border tax adjustment. A border tax adjustment is required to avoid a drop in EU competitiveness. This is especially needed when only the EU implements the policies. With the tax recycling or border tax adjustment, taxes paid by the industry are given partly back to the industry. However, the labour intensive sectors will benefit more than resource intensive sectors. Not all measures need a border tax adjustment though because many measures are implemented at the level of final consumption or extraction and therefore will not affect EU competitiveness.

Some policy measures firstly had to be translated into a model variable, in order to be compatible with the CGE model. For instance in Scenario 3 "Civil society leads' a specific modal split is achieved for the mobility of households. This split is 25 percent by car or plane, 35 percent by public transport and 40 percent walking. In the model this is translated into a

decrease in fuel consumption by households and an increase in the use of public transport services. Other measures did not have to be included explicitly. For instance the restrictions on government debt did not have to be included in the model because governments automatically adjust their spending according to their available budget in EXIOMOD.

The calculation of embodied materials is computationally difficult to implement. For some measures such as the "RMC based taxes" this would be needed though. This would require a simultaneous simulation run with both the IO and CGE mdel for each simulation year. Given the high number of countries and sector and thus to avoid computational problems, this measure is instead modeled as a tax at the source of extraction. The increased material costs will be passed through to the final products that embody the materials. The region extracting materials will have to cope with less demand for materials. In this way we can model the same effect in a technically feasible manner. The exact implementation of each policy measure into EXIOMOD is described in the summary table in Annex A: Implementation of policy measures into EXIOMOD 2.0.

With the implementation of the above policy mix the resource efficiency targets are not yet met. Additional assumptions are required to ensure that the targets will be met. We have to assume that additional efficiency improvements in the carbon, material and land intensity are achieved. For carbon intensity an additional improvement of 1.5 percent per year has to be assumed and for materials an additional annual improvement of 0.7 percent has to be assumed. The new material technologies have to be also used by non EU countries, because most of the EU RMC is imported from elsewhere. Only by making these additional assumptions we will be able to nearly meet the targets for CO2 emissions and materials use. Such technological improvements can be justified with the proposed policy measure called "EU innovation funding". With this policy measure part of the recycled tax revenues from the proposed policy mix are used for research to achieve futher resource efficiency improvements. Also the land use target is not yet met. We have to assume that countries with lower yields, or with the so-called yield gap, will invest in their technology to increase the land productivity. An additional annual improvement of 0.4 percent is required to meet the land use target. In each scenario we implement the same additional resource efficiency improvements.

Figure 4.1: Additional assumptions on resource productivity in order for the policy scenario to meet the targets, in annual % improvement.

	Reference scenario based on European Commission (2013; 2014) and FAO	**Policy scenario** including additional assumption on improvement
Carbon intensity	0.5%	2.0%
Material intensity	2.0%	2.7%
Yield	0.7%	1.1%

While modeling the policy measures one by one, we found that the policy measures for different resource efficiency targest could be conflicting with each other. For instance when only modeling policy measures targeted at CO2 emissions, the reduction in CO2 was larger than in combination with policy measures targeted at land and material use. This can be explained by the indirect rebound effect. In the example of CO2 related policy measures, the result is that energy demand decreases. The avoided expenditure on energy is spent on other products, which we call the indirect rebound effect. In case there would be additional policy measures for land use, demand for food will be reduced as well. The avoided expenditure on food is spent on other products including energy. Hence, we have a conflict between land use and CO2 related

policies. The marginal effect of the policy measures is lower when targeting four types of resources rather than one. However, we found that land and water use are not conflicting targets but were in fact complementary. Land or water use related policies affect both land and water use.

4.1 Scenario 1: Global cooperation

4.1.1 Assumptions

Scenario 1 “Strong cooperation” is characterized by international cooperation on environmental policy. The policy measures are implemented globally. The main policy measures in this scenario are the following.

- Royalties and/or taxes are put on the extraction of fossil fuels and metal ores of 65 EUR per tonne.
- A renovation rate of 3 percent is achieved in order to improve the energy efficiency in buildings. This leads to a reduction of 43 percent in household demand for heating.
- The eco-design standards become mandatory resulting in enhanced reusability and reparability of consumer durables. The demand for these durables is expected to decrease whereas the demand for maintenance and repair services is expected to double.
- Via an information program households are expected to reduce food waste by 33 percent.
- Most of the food waste is generated during the production and retail phase. We assume a reduction in food waste by 10 percent.
- A tax of 50 percent on meat is introduced.

A number of other measures is implemented as well. These are implemented in all three scenarios and will therefore not show much differentiation in the results compared to the other two scenarios. These includes:

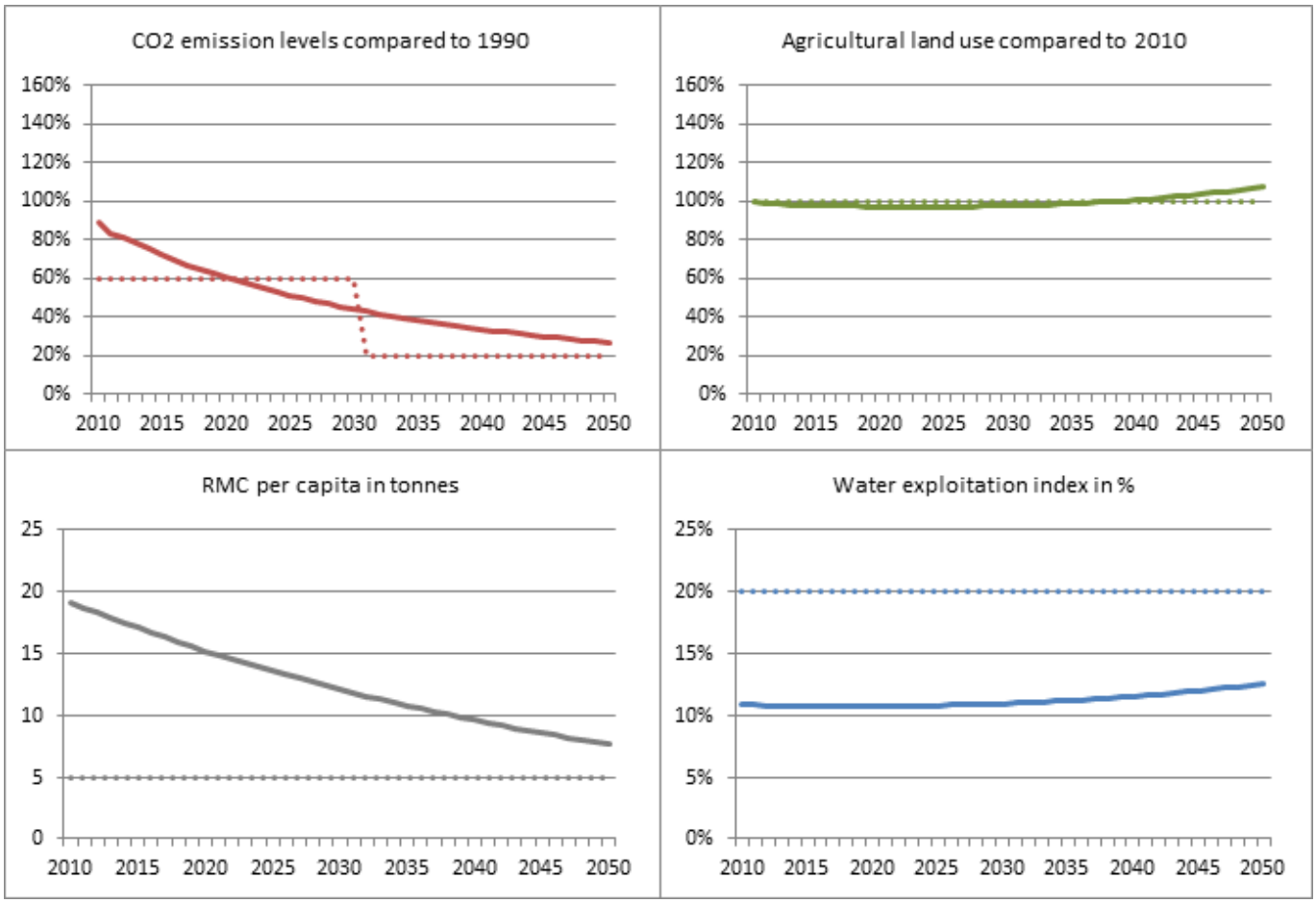
- Quota for renewable energy. Scenario 1 assumes that 90 percent of the electricity is produced from renewable energy sources.
- Also the CO2 intensity standards for cars and regulation of e-mobility in cities, leads to an energy mix of 80 percent electricity, 10 percent biomass and only 10 percent fossil fuel.
- In addition public transport is stimulated through a subsidy.
- Also a recycling quota for metals, non-metallic minerals and paper is implemented, which should achieve a recycled content of respectively 70, 85 and 85 percent.
- Additional assumptions on resource efficiency improvements to ensure that the resource effiency targets are met. This can be achieved with the policy measure “EU innovation funding” where recycled tax revenues are used for improvement in resource efficiency.

4.1.2 Results

The results regarding the four resource efficiency indicators are presented in Figure 4.2. Meeting the CO2, land and RMC targets requires the additional assumptions described in the beginning of Chapter 4. Only the water target is met without extra assumption and this was already the case in the reference scenario. Still the water exploitation index decreases by three

percentage points compared to the reference scenario by 2050 (compare Figure 4.2 with Figure 3.4) mainly thanks to the phasing out of nuclear energy and the lower economic activity, especially in agriculture.

Figure 4.2: Resource efficiency indicators in Scenario 1 and 2050 targets (dashed line) in the EU-27, 2010-2050



This scenario accentuate the decoupling between the economic activity and the resource use (compare Figure 4.3 with Figure 3.2). Whereas the GDP trajectory hardly changes compared to the reference scenario (see Figure 4.4), the resource use is lower for every indicator in every region (see Figure 4.5 to Figure 4.8). According to this scenario, resource efficiency can be achieved with a relatively small economic cost.

Figure 4.3: GDP and resource efficiency indicators in Scenario 1 in the EU-27, 2010=100

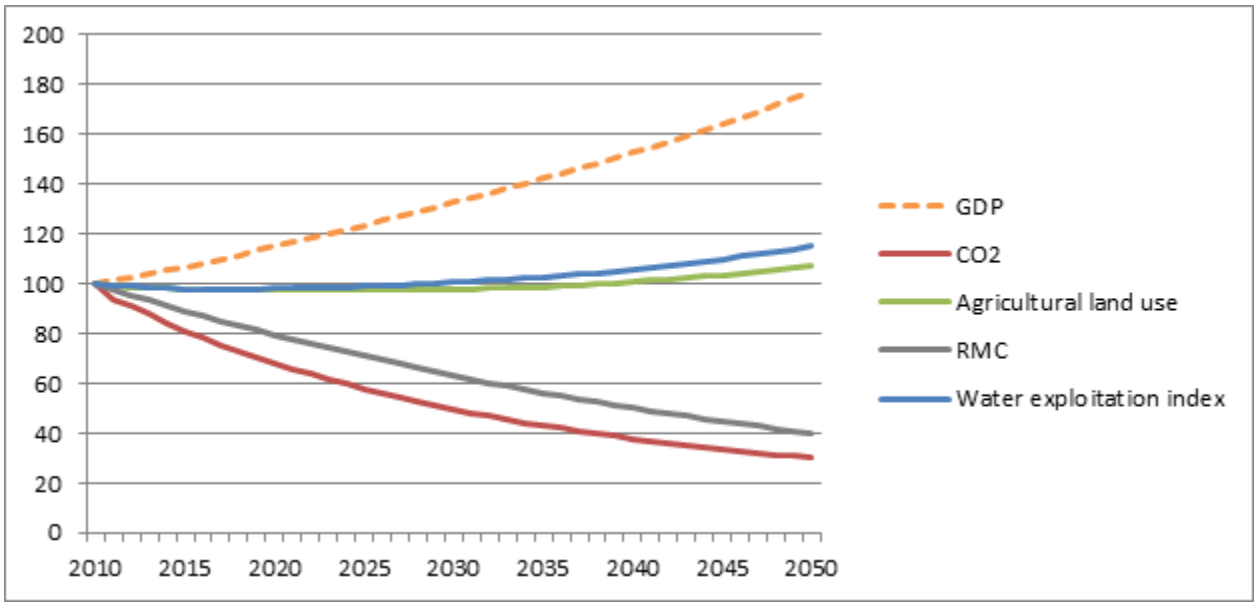
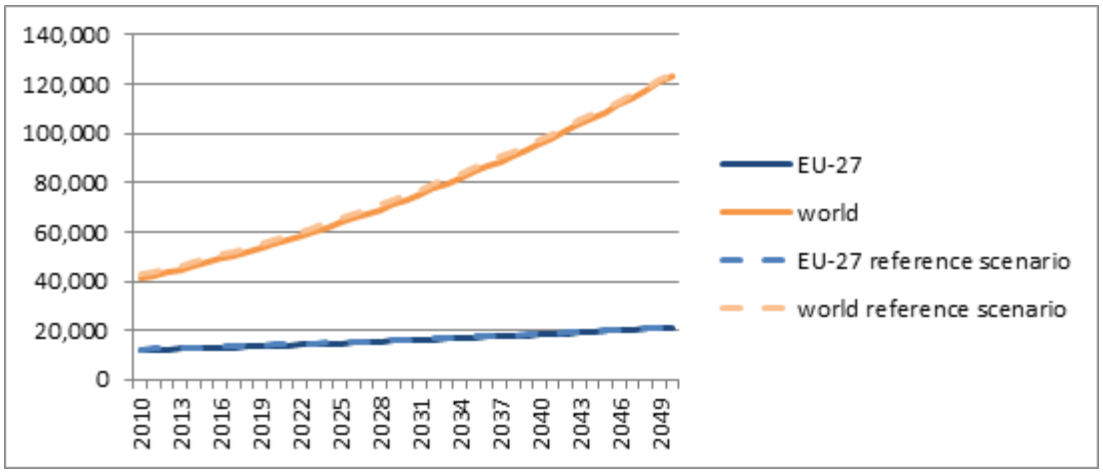


Figure 4.4: GDP in bln EUR in Scenario 1 and reference scenario, 2010-2050



At the world level, CO2 emissions decrease by 28 percent (see Figure 4.5). The EU performs the highest effort with a 50 percent decrease against a decrease of 36, 28 and 26 percent for respectively the United States, China and Japan. The global CO2 emissions are reduced by about 13 Gt, whereas to meet the global target CO2 emissions would have to a reduce by 35 Gt.

Figure 4.5: CO2 emissions Mt difference compared to reference scenario by region, 2050

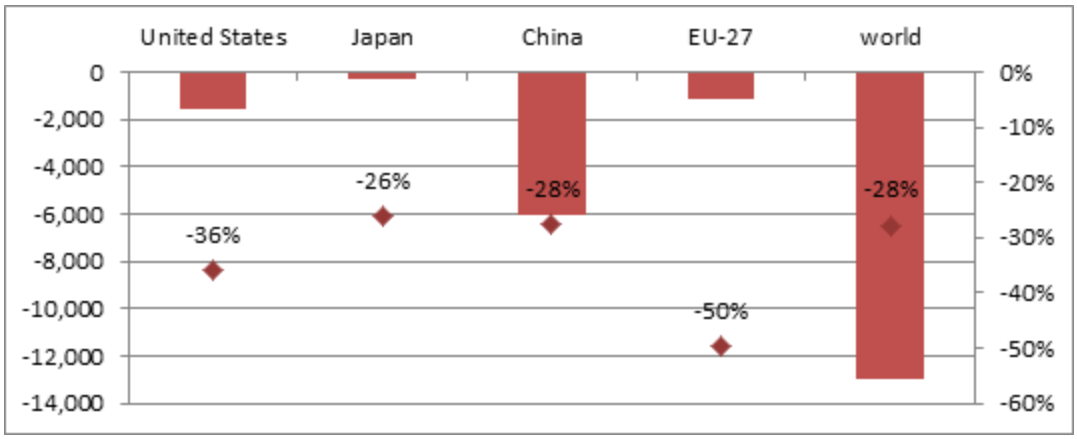


Figure 4.6 shows the impact of Scenario 1's policies on the use of abiotic and biotic materials. At the world level, their consumption decrease by more than 5 tonne per capita. In Europe, the decrease is higher (-8 tonne per capita). The decrease in nonmetallic minerals represents more than 70 percent of the total decrease. The implementation of eco-design standards and recycling quota explain a large part of this evolution. The measures for energy saving and the CO2 tax explains the reduction in fossil fuel consumption. Recycling measures are the main factor explaining the decrease in metallic mineral. The reduction in biomass use is explained by the reduction of food waste and the reduction of meat products due to the implementation of a tax of 50 percent on meat. This reduction more than compensates the increase in biomass from the increase in biofuel production.

Figure 4.6: RMC for abiotic and biotic material in tonne per capita compared to reference scenario, 2050

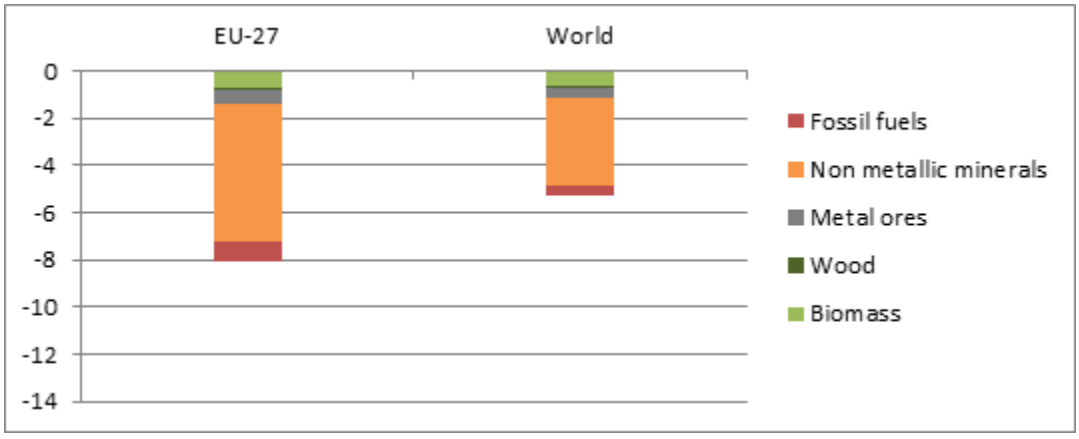


Figure 4.7 and Figure 4.8 show the decrease in land use and water abstraction due to the implementation of Scenario 1. The use of these two resources is largely related to the agricultural sector. Therefore the reduction in their use come from the policy implemented to limit agricultural activities (reduction of food waste and the reduction of meat products). For both resources, the decrease observed in Europe is in the same order of magnitude as in the World: -26 percent for land use and -16 percent for water consumption.

Figure 4.7: Land use in mln ha difference compared to reference scenario by region, 2050

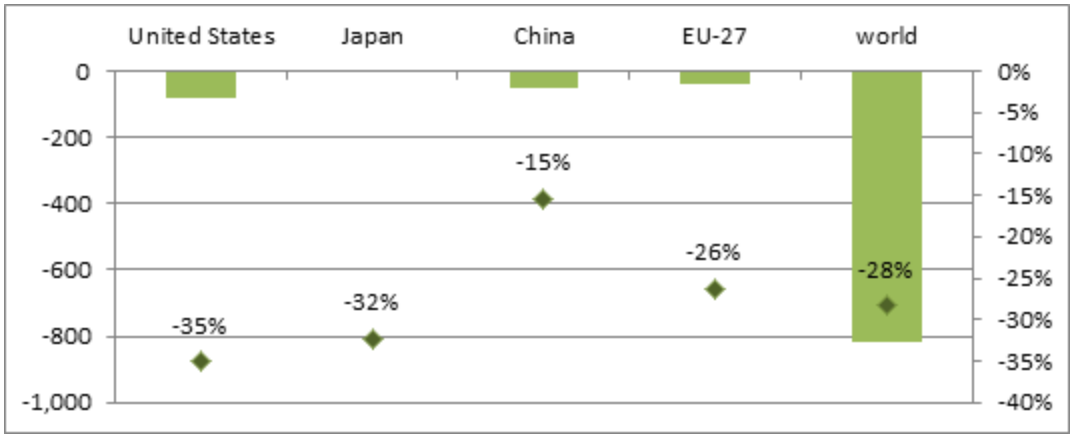
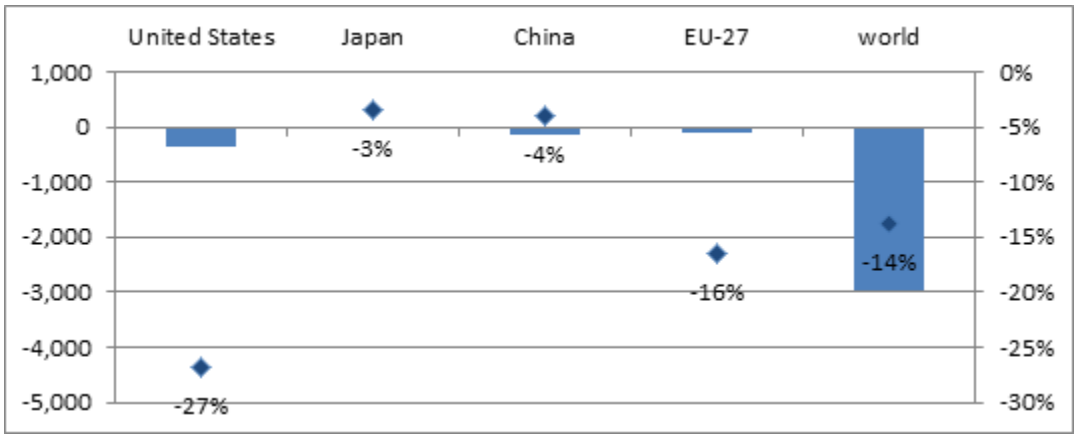


Figure 4.8: Water abstraction in km3 difference compared to reference scenario by region, 2050

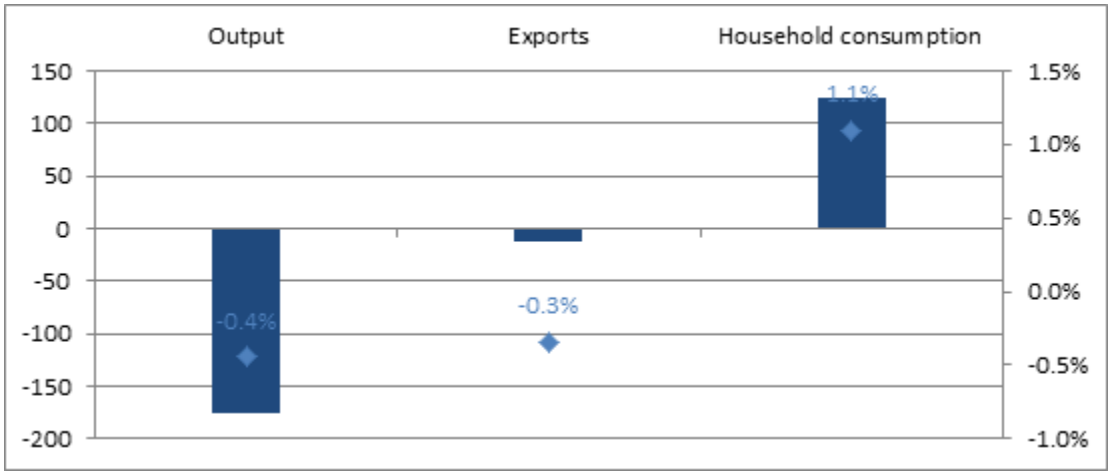


Scenario 1 leads to an increase of 1.1 percent in households consumption while at the same time output or production decreases by 0.4 percent (see Figure 4.9). This can be explained by the tax recycling which is part of the environmental tax reform (ETR). The effect mainly comes from two mechanisms:

- The resource tax revenues are for 50 percent redistributed to households which prevent a decrease in the real revenue.
- The other 50 percent are redistributed via a reduction of the employer social contribution which gives an incentive to substitute energy to labor. Because the labor stock is fixed, wages and therefore household's income increase.

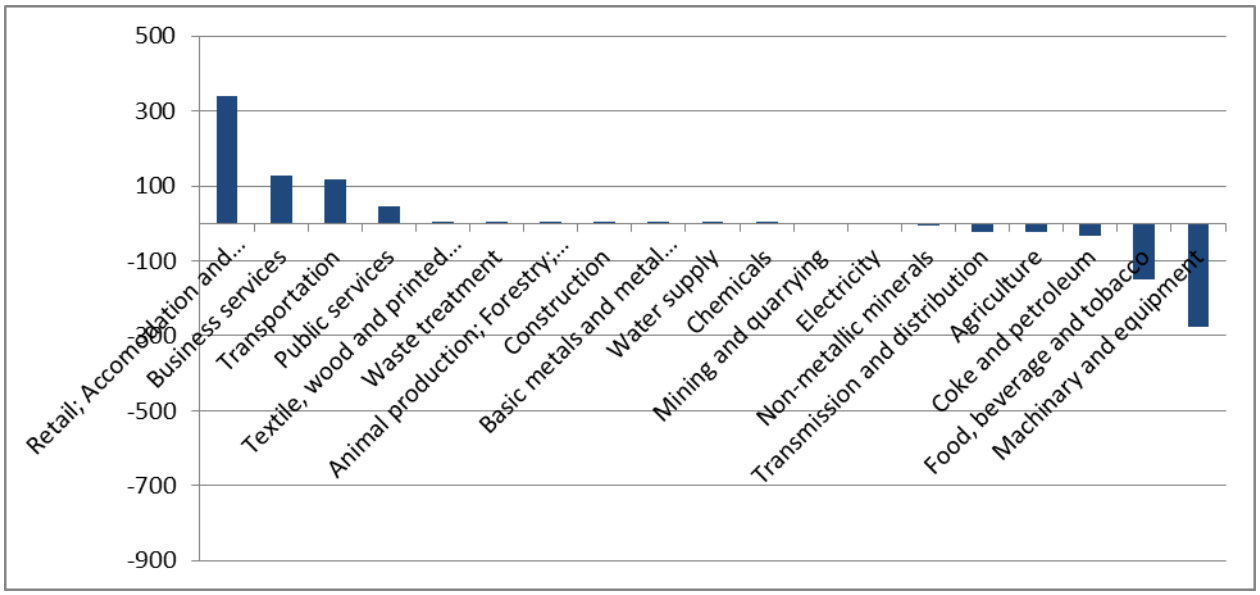
The compensation mechanism is less favorable for companies with an increase of their production cost. This lead to a decrease in competitiveness and of export and at the end of output.

Figure 4.9: Total output, exports and household consumption in bln EUR difference compared to reference scenario in the EU-27, 2050



The policy implemented in this scenario leads to changes in consumption pattern. Resource intensive products become relatively more expensive, given an incentive to consumers to buy the most resource efficient products. This can be seen in Figure 4.10 where the consumption of agricultural, food, energy products decreases. On the contrary, we observe an increase in the consumption of services including public transport.

Figure 4.10: Household consumption by product in bln EUR difference compared to reference scenario in the EU-27, 2050



4.2 Scenario 2: EU goes ahead

4.2.1 Assumptions

Most of the policy measures implemented in Scenario 2 are comparable with those from the previous scenario. However, measure which are specific ton this scenario are only implemented in the EU. Scenario 2 specific measures are listed below. These are implemented on top of the policy measures which are assumed in the same way (at global level) in all three policy scenarios.

- A reformed ETS with a carbon price of 75 EUR per tonne of CO2.
- A carbon tax for non ETS sectors (list of ETS sectors can be found in Annex B: List of regions and sectors) using the same carbon price of 75 EUR per tonne of CO2.
- The renovation rate for buildings reaches 3%, improving energy efficiency in the built environment. This is achieved through a subsidy.
- A RMC based tax for metals and non-metallic minerals of 65 EUR per tonne of material.
- A tax on water withdrawal of 0.50 EUR per m3. This includes both temporary and permanent water abstraction.
- Reduction of food waste for producers with 10%.
- A tax on meat of 50%.

4.2.2 Results

Like Scenario 1, this scenario also features the decoupling between the economic activity and the resource use (compare Figure 4.11 with Figure 3.2). Although the GDP trajectory is only slightly below the trajectory under the reference scenario (see Figure 4.11), the resource use is much lower for every indicator in every region (see Figure 4.12 to Figure 4.15). In this scenario, resource efficiency can be achieved with a relatively small economic cost.

Figure 4.11: GDP and resource efficiency indicators in the EU-27 in Scenario 2, 2010=100

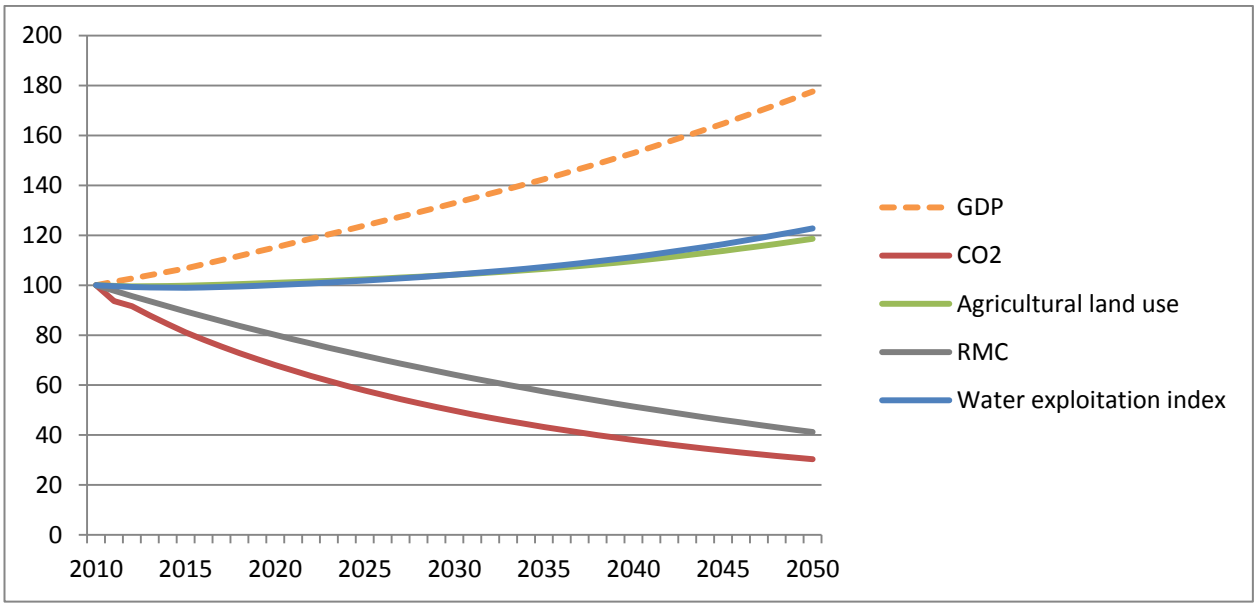
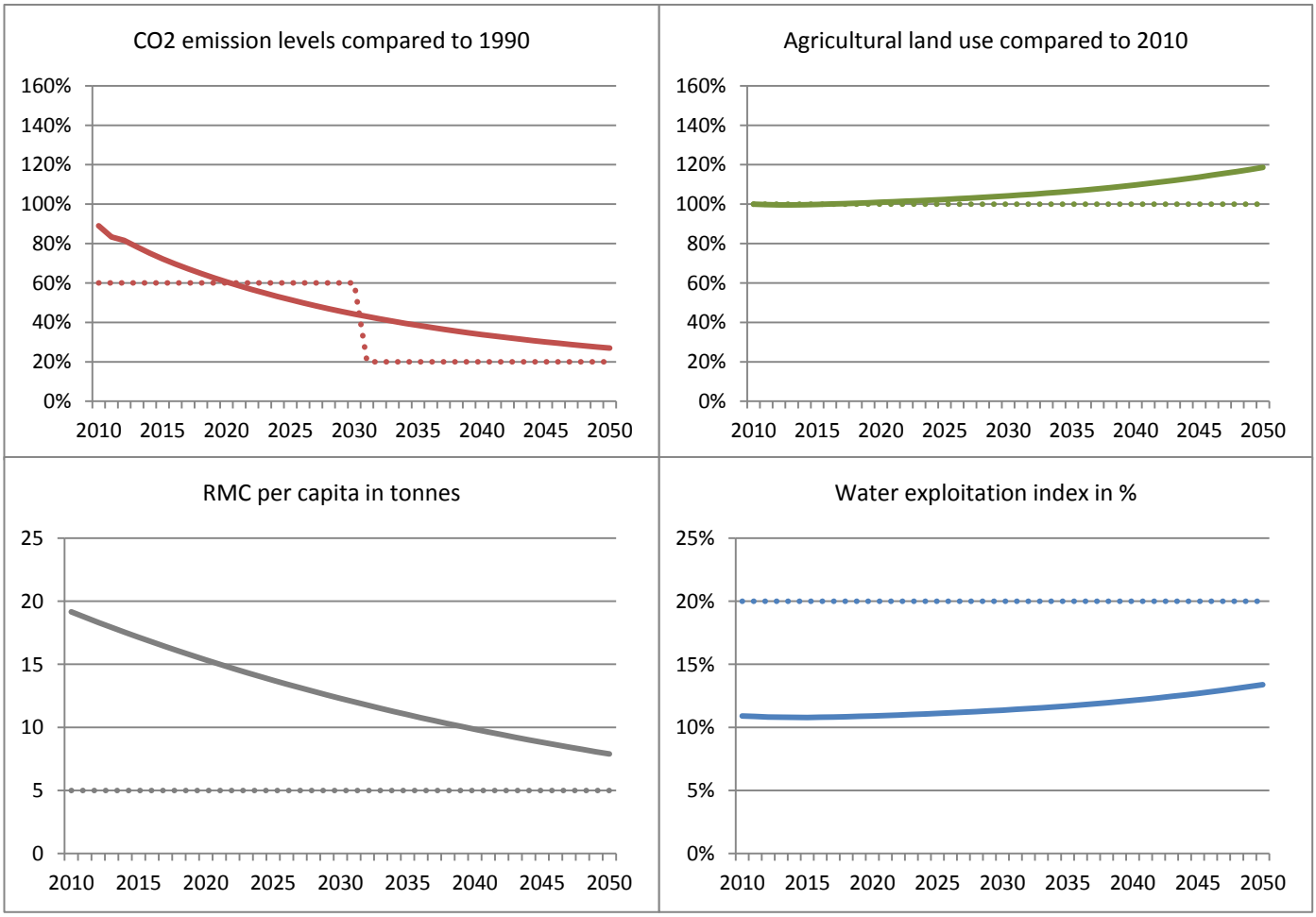
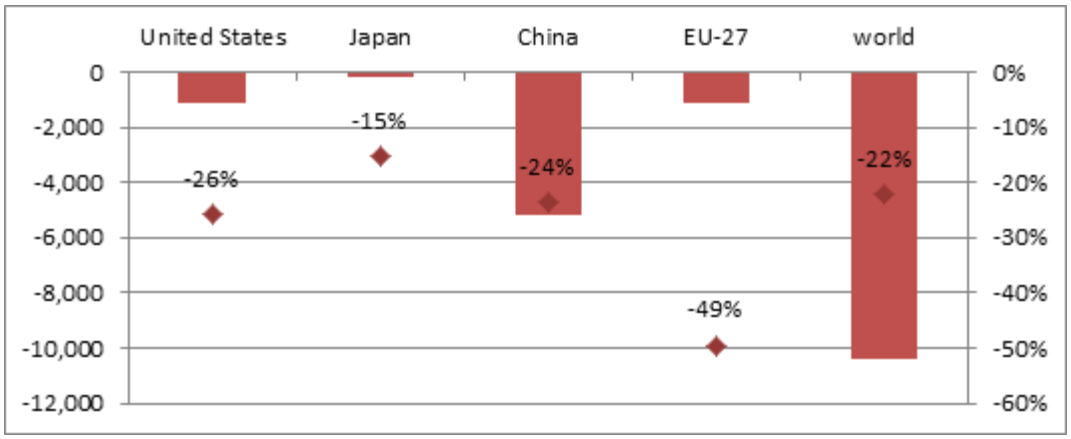


Figure 4.12: Resource efficiency indicators in Scenario 2 and 2050 targets (dashed line) in the EU-27, 2010-2050



The difference of the level of CO2 emission compared to the reference scenario in 2050 and for each of the five regions is shown in Figure 4.13. Among all the regions, EU performs the highest effort with a 49 percent decrease against a decrease of 26 percent, 24 percent and 15 percent for respectively the United States, China and Japan. This is caused by the fact that many of the low-carbon energy related policy measures are only implemented in the EU. This includes the implementation of a reformed ETS in the EU with a carbon price of 75 EUR per tonne of CO2 and a second carbon price for non ETS sectors in the EU. Yet a light version of these policy measures are implemented in the other World's regions. These together with the assumption of additional improvements in carbon intensity will result in 22 percent reduction in the World CO2 emissions in 2050 compare to the reference scenario.

Figure 4.13: CO2 emissions in Mt difference compared to reference scenario by region, 2050



The impact of the implementation of the policy mix under Scenario 2 on the use of abiotic and biotic materials are summarized in Figure 4.14. At the World level, there is a reduction of about five tonne per capita. In the EU, there is a larger reduction of about eight tonne per capita. The decrease in non-metallic minerals represents more than 70 percent of the total decrease in the EU. The implementation of a RMC based tax on the use of metals and non-metallic minerals in final demand, recycling quota explain a large part of this evolution. The measures for energy saving and the CO2 tax explains the reduction in fossil fuel consumption. Recycling measures are the main factor explaining the decrease in metallic minerals. The reduction in biomass use is explained by the reduction of food waste and the reduction of meat products due to the implementation of a tax on meat. Like Scenario 1, this reduction more than compensates the increase in biomass from the increase in biofuel production.

Figure 4.14: RMC by abiotic material in tonne per capita difference compared to reference scenario, 2050

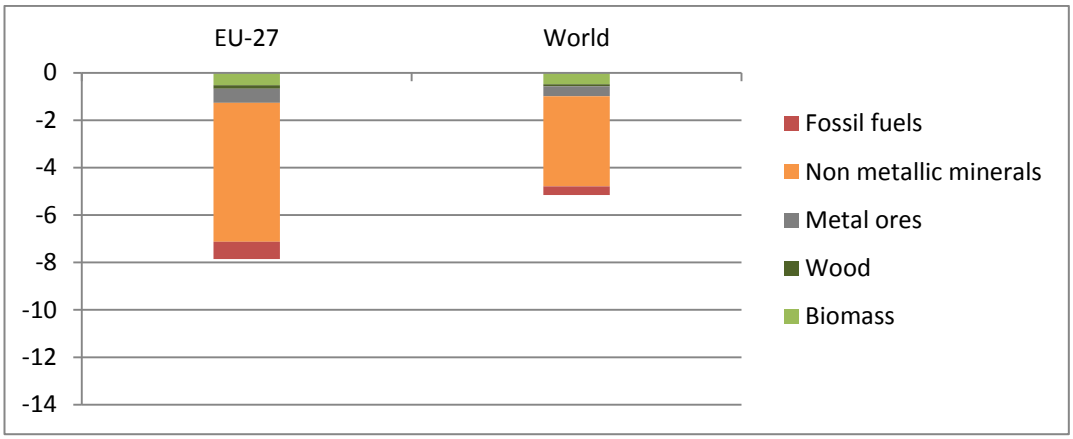


Figure 4.15and Figure 4.16 show the decrease in land use and water abstraction in 2050 compared to the reference scenario due to the implementation of Scenario 2's policy measures. The use of these two resources is largely related to the agricultural activities and the reduction in land and water use come from the policy implemented to limit these activities (reduction of food waste and the reduction of meat products). The decrease observed in the EU is in the 19 percent for land use and 11 percent for water consumption.

A reduction of land use in the same magnitude as the EU is observed for the World (about 18 percent). This is due to the fact that land intensive products are imported to a large extent. Through trade flows the EU demand for food affects the land use in the rest of the world. Moreover, in Scenario 2 it is assumed that there will be an increase in land productivity for countries with a yield gap due to the investment in new technologies. We would expect that same trend for water because water and land are complementary in the production of food. However, water has more purposes such as cooling in the electricity sector and the final use by households. The water withdrawal tax in this scenario leads to strong a reduction in water use reduction in the EU.

Figure 4.15: Land use in mln ha difference compared to reference scenario by region, 2050

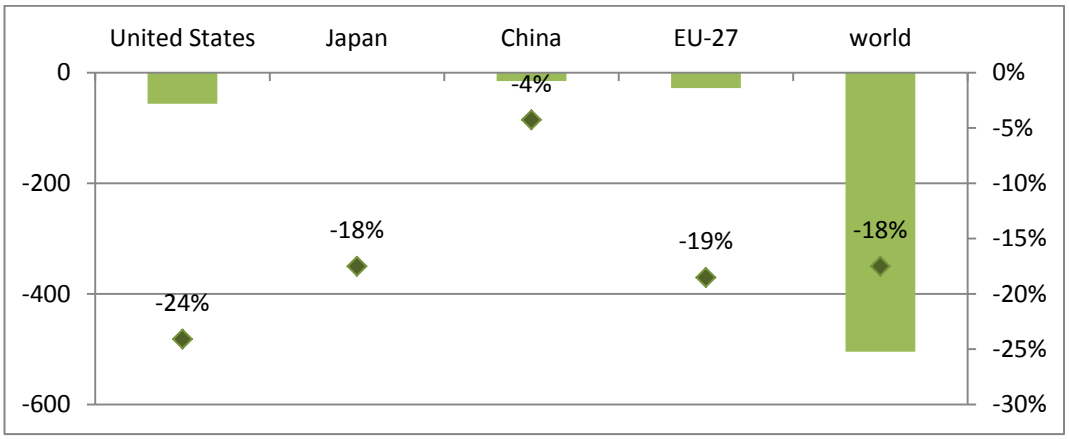


Figure 4.16: Water abstraction in km3 difference compared to reference scenario by region, 2050

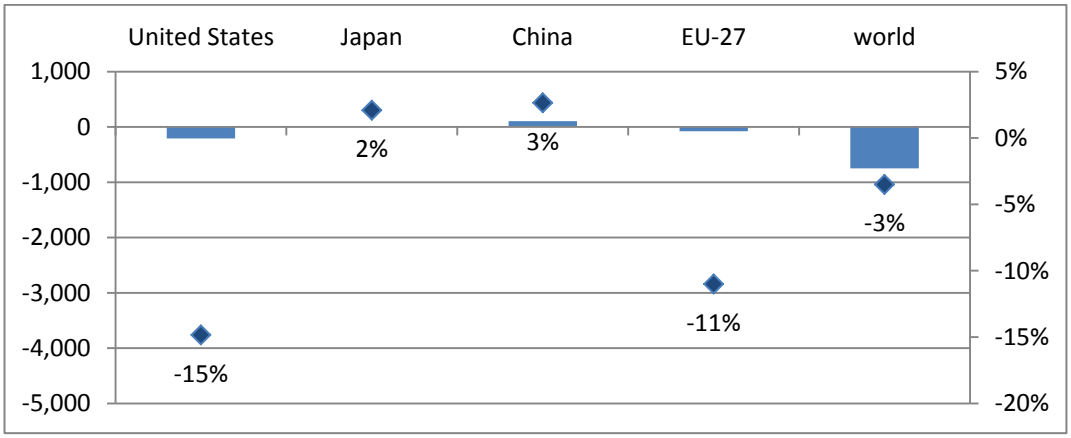
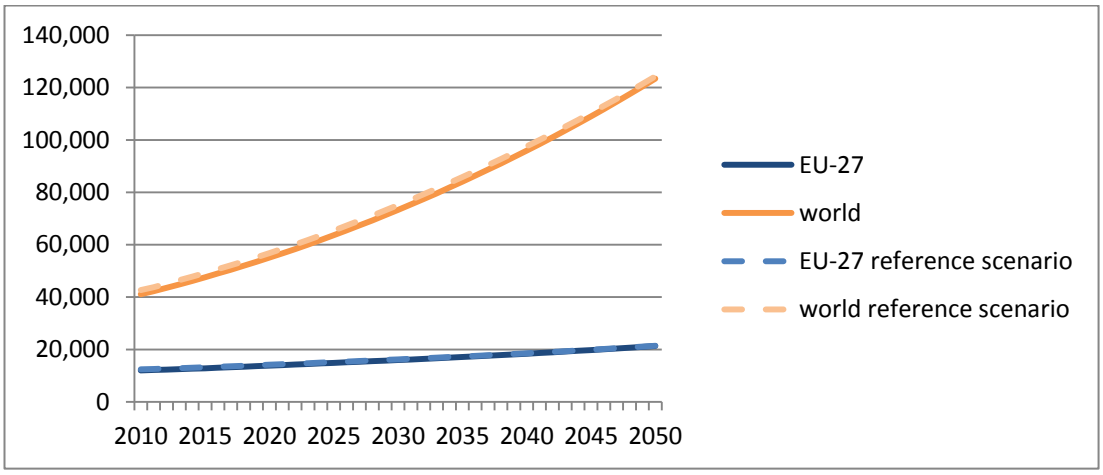


Figure 4.17: GDP in bln EUR in Scenario 2 and reference scenario, 2010-2050



The effects of environmental tax reform are stronger in this scenario because there are more environmental taxes that are recycled. The labour intensive sectors benefit from the tax recycling and can export more. Also the households benefit and have more to spend. There is some substitution to imported products from non EU regions without additional taxation. The domestic EU market therefore decreases and firms will focus more on the international market. Hence, we see an increase in exports of 2.2 percent compared to the reference scenario and in increase in household consumption of 0.9 percent (see Figure 4.18).

Figure 4.18: Total output, exports and household consumption in % difference compared to reference scenario in the EU-27, 2050

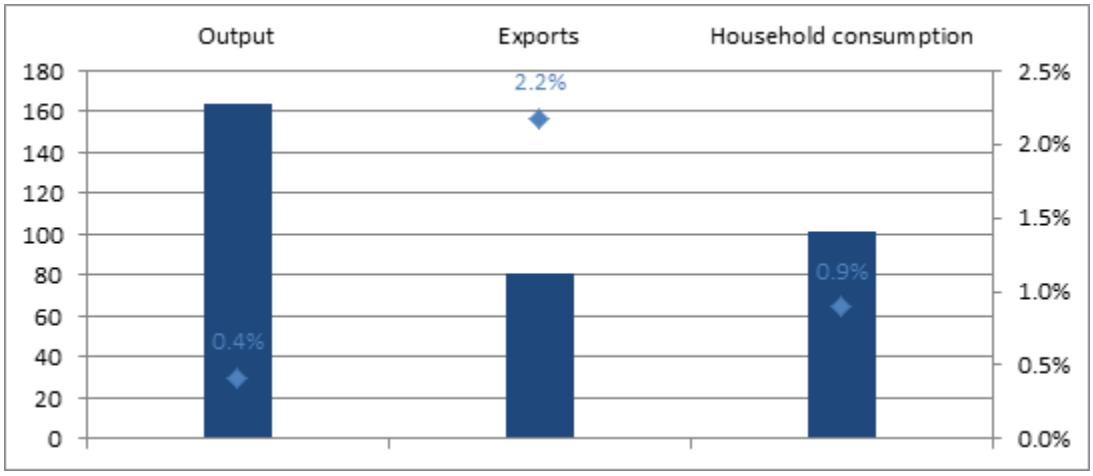
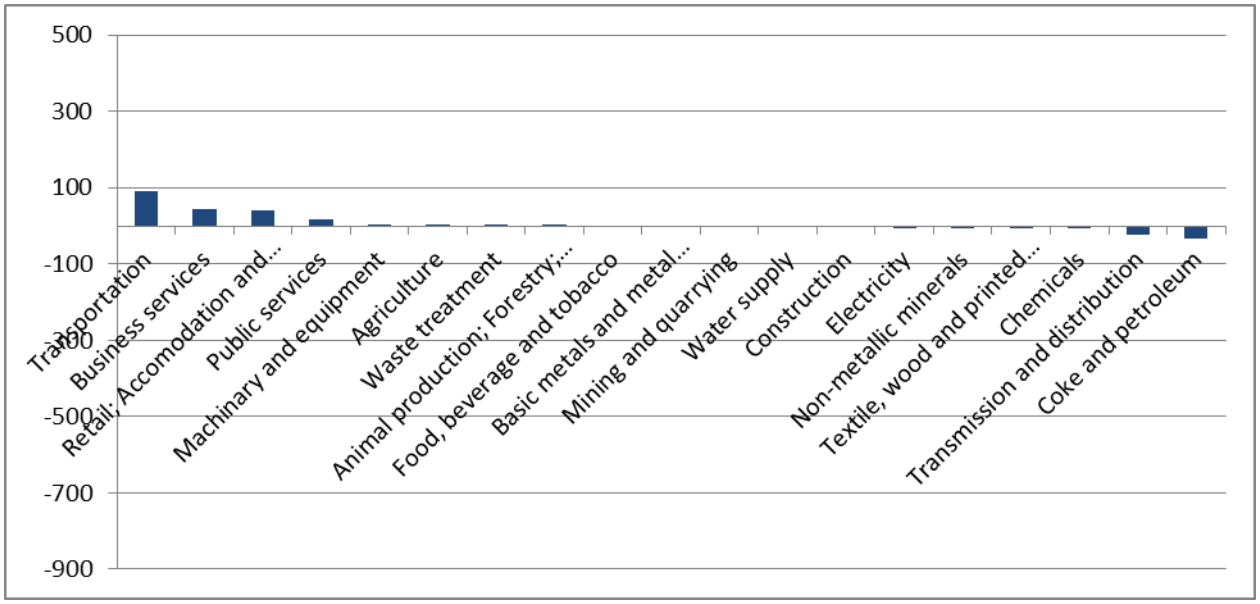


Figure 4.19: Household consumption by product in bln EUR difference compared to reference scenario in the EU-27, 2050



4.3 Scenario 3: Civil society leads

4.3.1 Assumptions

The results of Scenario 3 “Civil society leads” are mainly triggered by an intrinsically driven reduction in materialism, or in other words a reduction in working week and household consumption. The working week is reduced from five to four working days and on top of the loss of income, households are going to save 15 percent from their income additionally.

Significant reduction in the consumption for certain product groups are assumed, for example in transportation. A modal split is assumed of 25 percent by car or plane, 35 percent by biking and

40 percent by walking. This modal split is combined with an autonomous reduction in overall transport. Also meat consumption decreases significantly because half the population becomes vegetarian. Lastly, in general environmentally harmful goods in terms of energy and materials are consumed less.

Different standards of living will lead to a rising willingness to use a shared house. Some studies have shown new modes of living such as the multi-generation house (Mahdavi et al, 2012). We assume that 20 percent of the households will use shared houses and as a result their demand for space heating will be reduced by 50 percent.

Top down measures include the reformed ETS and carbon taxation for non ETS sectors and households. A carbon price of 75 EUR per tonne of CO2 is implemented. Also mandatory eco-design standards are implemented which prolong the lifetime of consumer durables. This reduces the demand for durables by 75 percent but doubles the demand for maintenance and repair services.

The other measures which are similar to the first two scenarios are a quota for renewable energy, CO2 intensity standards for new cars, regulations for e-mobility in cities, recycling quota for metals, non-metallic minerals and paper, and subsidies public transport. In this scenario all the measures and behavioural changes are only assumed in the EU-27.

4.3.1 Results

In this section, the results of simulations of policy packages under the assumption of Scenario 3 are presented. The simulation results of Scenario 3 for the four resource efficiency indicators are shown in Figure 4.20. Meeting the CO2, land and RMC targets requires the implementation of additional assumptions which were described in the beginning of Chapter 4. Like Scenario 1 and 2, here only the water target is met without these extra assumptions.

This scenario accentuate the decoupling between the economic activity and the resource use (compare Figure 4.20 with Figure 3.2). The GDP trajectory is now below the reference scenario (about 15 percent below in 2050). This reduction is a direct consequence of what lies in the core of Scenario 3, a world with intrinsically driven reduction in materialism and mainly caused by the reduction in working week and household consumption.

The resource use indicators for Scenario 3 and its targets are shown in Figure 4.21. For all the indicators and all the regions, the resource use is lower than the reference scenario. In this scenario, resource efficiency is achieved with a relatively higher cost compare to the other two scenarios.

Figure 4.20: GDP and resource efficiency indicators in the EU-27 in Scenario 3, 2010=100

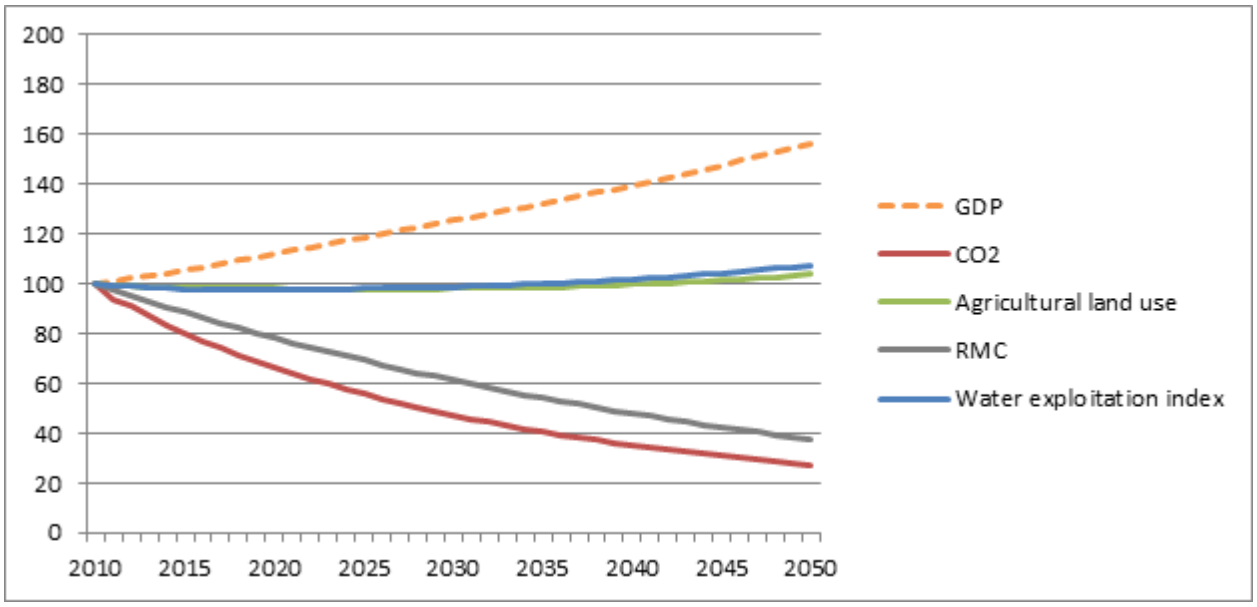
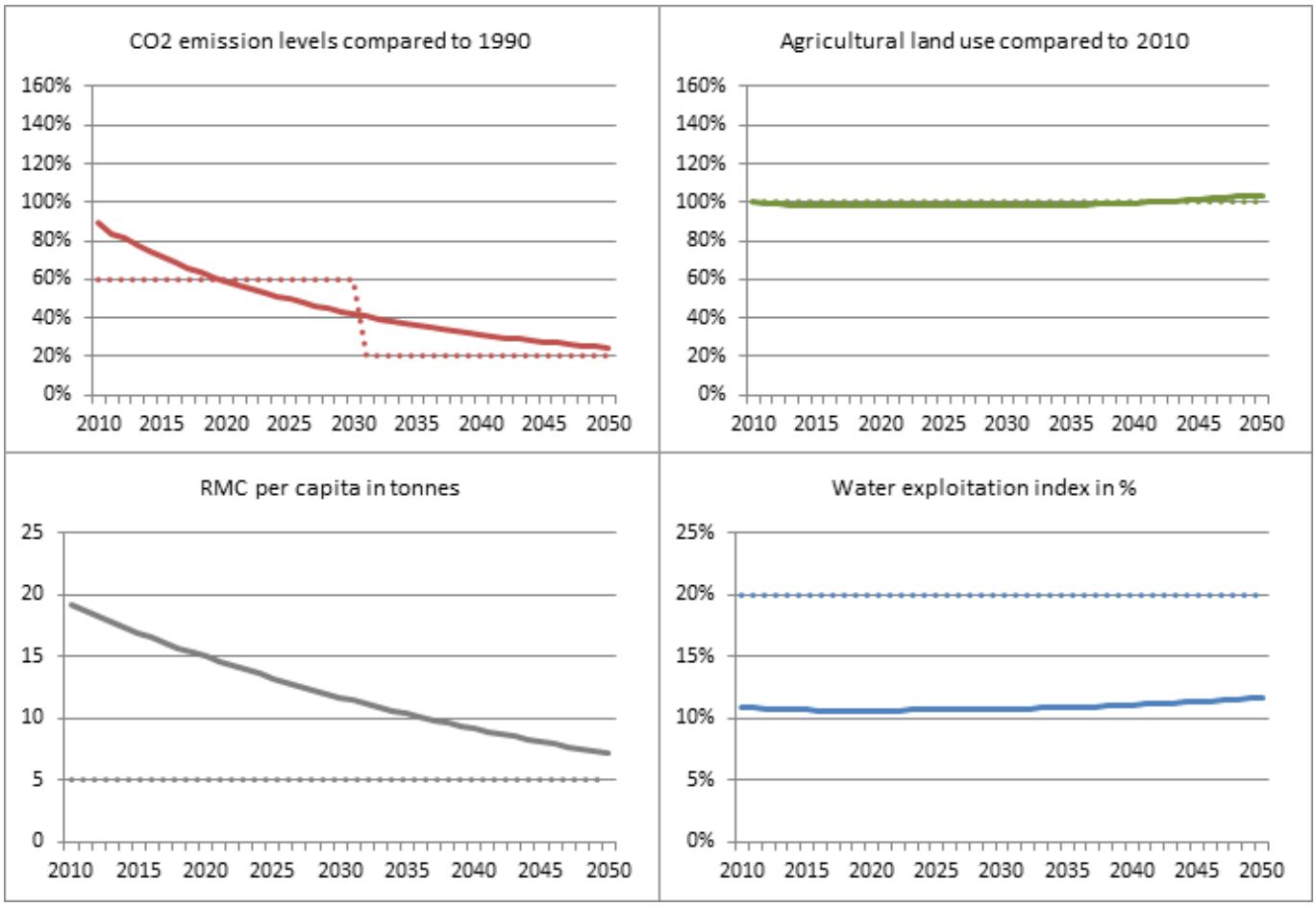


Figure 4.21: Resource efficiency indicators in Scenario 3 and 2050 targets (dashed line) in the EU-27, 2010-2050



At the world level, CO2 emissions decrease by 25 percent (see Figure 4.22). The EU performs the highest effort with a 55 percent decrease against a decrease of 28 percent, 27 percent and 19 percent for United States, China, and Japan respectively. This is caused partly by the reformed ETS and carbon tax for non ETS sectors and households, CO2 intensity standards for new cars, regulations for e-mobility in cities, as well as and the change in the lifestyle (e.g. sharing houses) in the EU. But, the main contributing factor is a reduction in economic activity due to the reduced working week. Moreover, in the EU countries private households will autonomously substitute private mobility expenditures by public transport services which also contributes to the reduction of CO2 emission. The reduction of CO2 emissions in other regions can be explained partly by the fact that the autonomous reduction of consumption of the environmentally harmful commodities in the EU-27 will hold for both imported and domestic products.

Figure 4.22: CO2 emissions in Mt difference compared to reference scenario by region, 2050

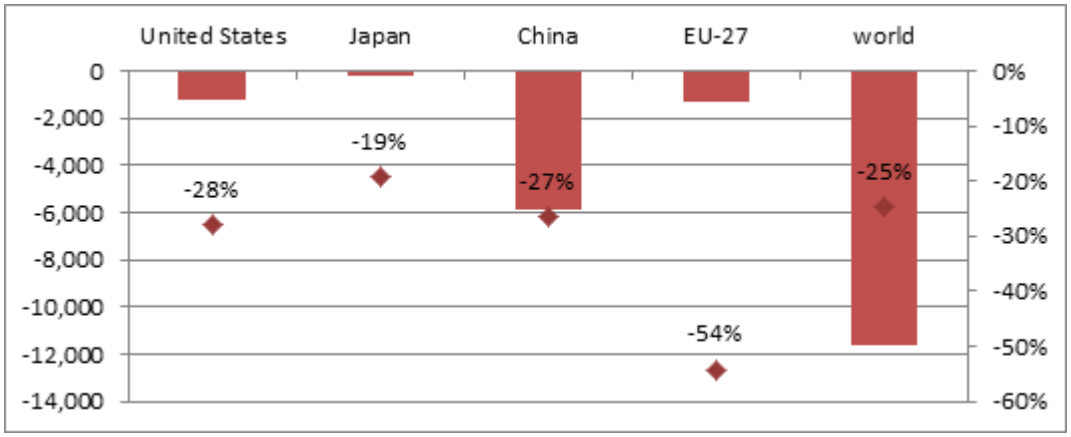
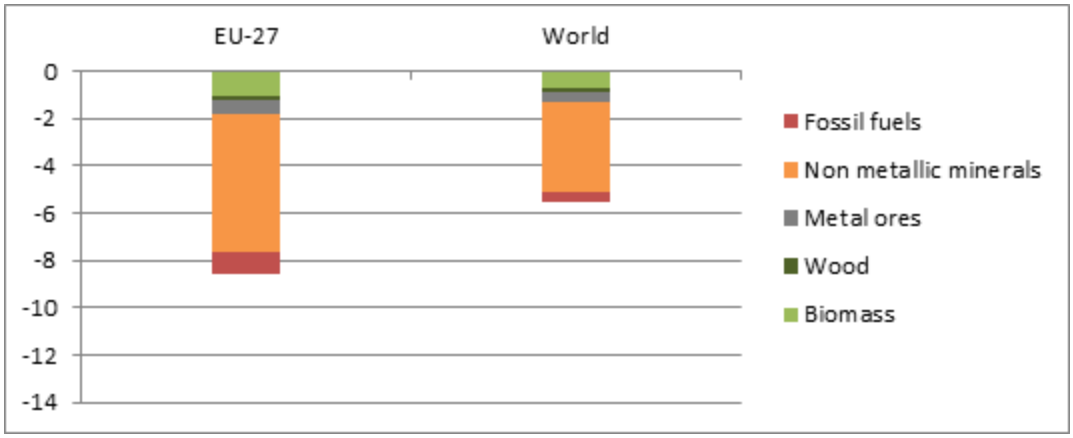


Figure 4.23 shows the impact of the implementation of the policy packages under Scenario 3 on the use of abiotic and biotic materials. At the world level, the aggregate use of these materials is decreased by nearly 6 tonne per capita. In Europe, the decrease is higher (more than 8 tonne per capita). The decrease in non-metallic minerals represents more than 65% of the total decrease. The autonomous reduction of demand for environmentally harmful commodities is the result of intrinsic motivation of consumers. This means that especially the common use of the material intensive consumer durables which is organized privately outside the economy. The common use will raise the efficiency of the stocks of durables which finally reduces the demand for these products. Further an autonomous reduction of total private consumption in EU countries is assumed. This is plausible, because the reduction of consumer durables is not substituted by an increase in other consumption categories. In addition to these, the implementation of mandatory eco-design standards and recycling quota in the EU explain a large part of this evolution. Recycling quota for materials and reduction in the total consumption in the EU are the main factor explaining the decrease in non-metallic minerals. The reduction in biomass use is explained by the reduction of total EU consumption, reduction of meat consumption, and reduction of food waste. This reduction compensate the increase in biomass which results from the increase in biofuel production.

Figure 4.23: RMC by abiotic material in Mt difference compared to reference scenario, 2050



The change in the land use and water abstraction as a result of the implementation of Scenario 3 and in comparison with the reference scenario is presented in Figure 4.24 and Figure 4.25. The decrease in land use and water abstraction is observed in all the regions. The use of these two resources is largely related to the agricultural activities. In Scenario 3, consumers reduce their food waste by intrinsic motivation. On average there is a share of 33 percent avoidable food waste and thus a reduction of one third until 2050 (Ref). Moreover, in the EU countries there will be an autonomous reduction of meat consumption driven by intrinsic motivation.

In the other regions also a decrease in land use is observed. This is due to three main factors: the assumption about the increase in land productivity due to the investment in new technologies; the expansion of agricultural land use is restricted in all countries, and the fact that the autonomous reduction of food consumption in the EU, as described above, also holds for imported products.

Figure 4.24: Land use in mln ha difference compared to reference scenario by region, 2050

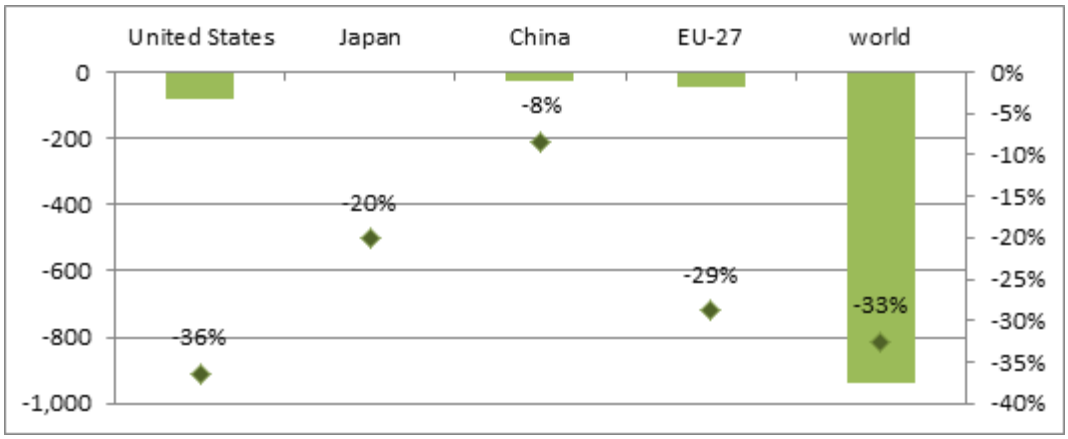


Figure 4.25: Water abstraction in km3 difference compared to reference scenario by region, 2050

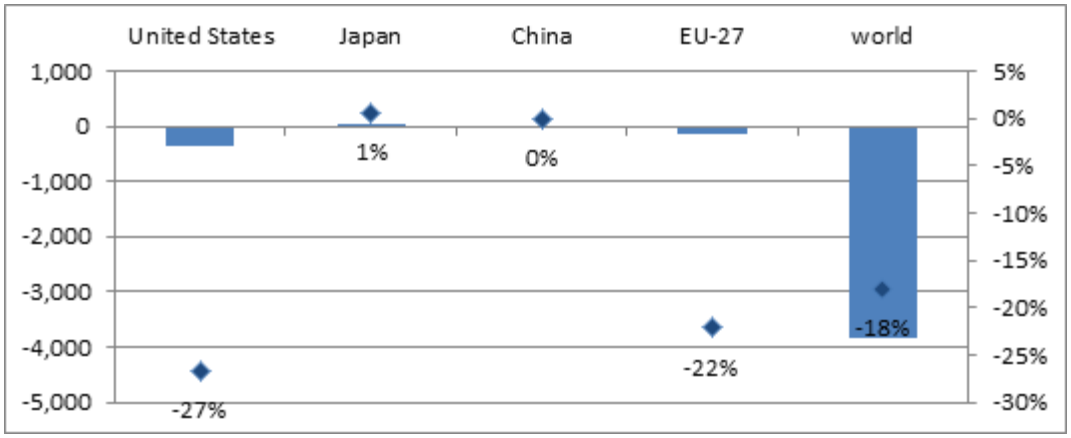
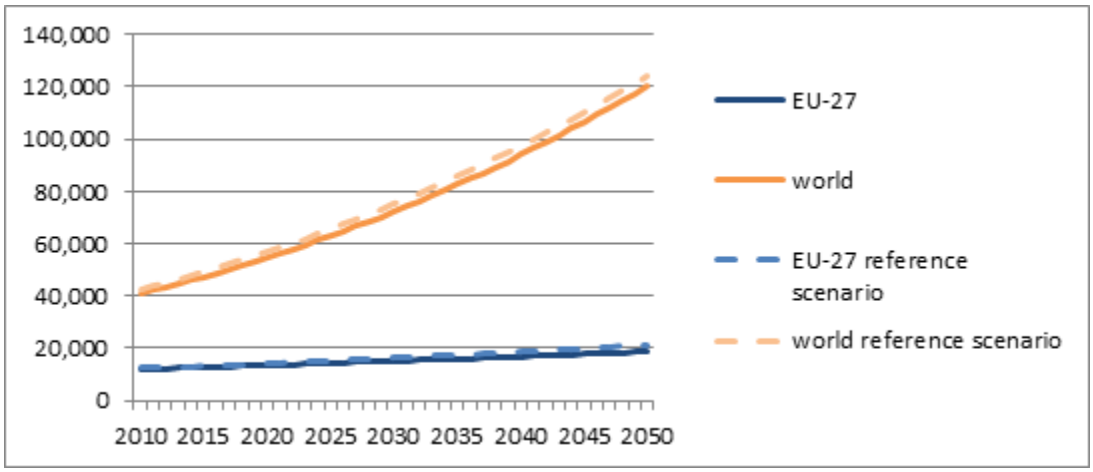


Figure 4.26: GDP in bln EUR difference in Scenario 3 and reference scenario, 2010-2050



Scenario 3 leads to a decrease of 26 percent of the total households consumption in the EU-27 compare to the reference scenario. Figure 4.28 shows that this holds for all the categories of products but mostly for the luxury products. The model distinguishes between consumption of luxury and neccessity goods. When households will consume less, they will mainly consume less of luxury products which include all services and machinery and equipment. In Scenario 3 an autonomous reduction of total private consumption in EU countries is assumed. The total output will also be decreased by about 11 percent (see Figure 4.27). This is caused by the assumptions that for the EU countries in the long run labor supply (average yearly working hours per employee) is reduced. More time for family life, social relations and leisure is demanded in this scenario in comparison to the reference scenario. Consequently, as shown in Figure 4.26, the projected GDP (both EU-27 and the World) under Scenario 3 is below the one from reference scenario.

Figure 4.27: Total output, exports and household consumption in bln EUR difference compared to reference scenario in the EU-27, 2050

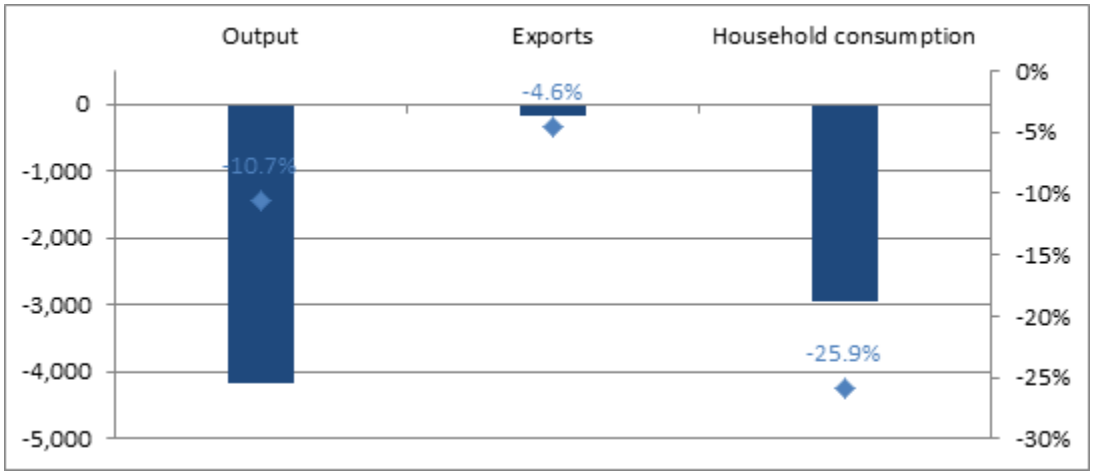
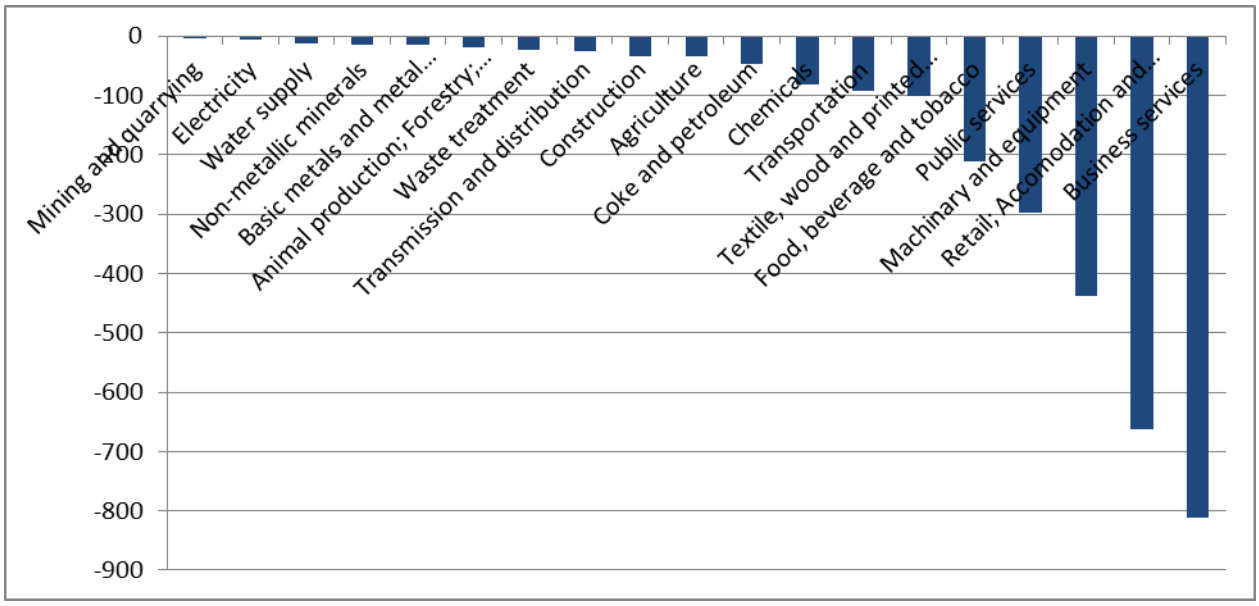


Figure 4.28: Household consumption by product in bln EUR difference compared to reference scenario in the EU-27, 2050

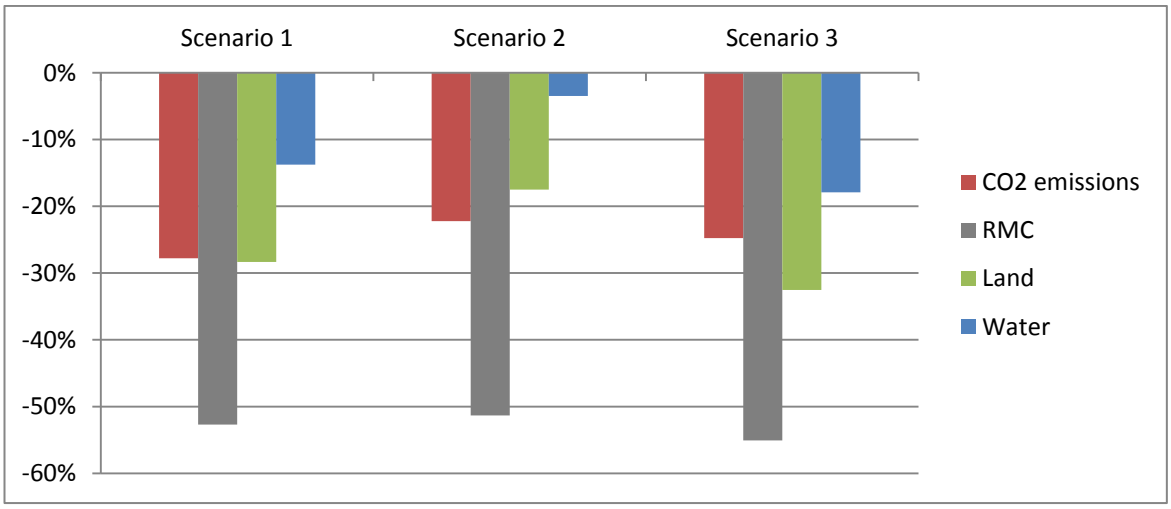


5 Conclusions

This research investigates the impact of alternative policy scenarios aiming at decoupling socio-economic activities with resource use. This idea is to make the economic trajectories of resource demand compatible with environmental potentials and constraints. More particularly, we have focused on three different socio-economic pathways or visions of possible futures (described in Task 3.2): Scenario 1 “Global cooperation”; Scenario 2 “EU goes ahead”; Scenario 3 “Civil society leads”.

Because of a global policy, the implementation of the policy mix under Scenario 1 results in a higher reduction in CO2 emissions compared to the other two scenarios. However the difference is not very large. Under Scenario 1, CO2 emissions decrease by about 29 percent in 2050 compared to the reference scenario against 21 percent reduction in Scenario 2 and 24 percent reduction in Scenario 2 (see Figure 5.1). The overall reduction in all three scenarios is caused by the reformed ETS and carbon tax for non ETS sectors and households, CO2 intensity standards for new cars, and the regulations for e-mobility in cities. But, the main contributing factors for a better performance in Scenario 1 is that the severance tax rate on fossil fuels, renewable energy quota and other measures will be implemented globally to reduce generally CO2 emissions, whereas in the other two scenarios these measures are only implemented in the EU.

Figure 5.1: World reduction in CO2 emissions, RMC, land and water use per in % difference compared to reference scenario, by scenario, 2050



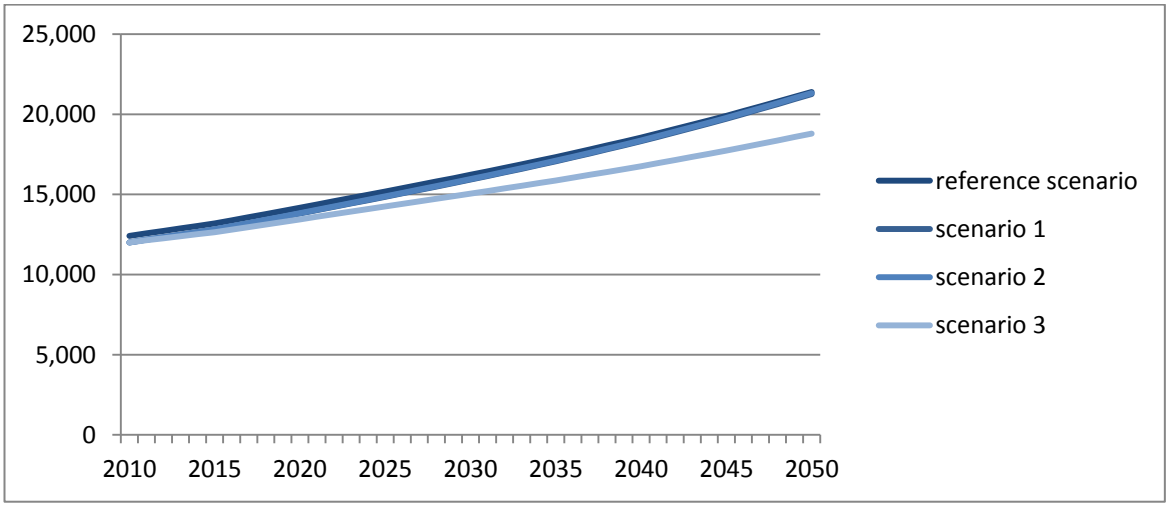
A slightly better performance of Scenario 3 for RMC, land and water targets compared to Scenario 1 is caused by the Scenario 3’s specific assumptions regarding a reduced working week. This directly leads to lower economic growth and hence lower environmental pressure through less consumption of goods.

The implementation of the policy mix in combination with the assumed behavioural changes under Scenario 3 results in a bit higher decrease in RMC compared to the other two scenarios. Under Scenario 3, RMC decreases by about 55 percent in 2050 against 52 percent decrease in

Scenario 1 and 51 percent decrease in Scenario 2 (see Figure 5.1). The overall reduction in all three scenarios is caused by the measures which are implemented in all scenarios including quota for renewable energy, recycling quota and CO2 standards for cars.

In all scenarios, GDP growth decreases (see Figure 5.2). This is marginal in Scenario 1 and 2 in comparison to the GDP increase over the all period. In Scenario 3, the relative GDP decrease is substantial but this has the counterpart of a substantial decrease in working hours.

Figure 5.2: GDP in bln euro in the EU-27 by scenario, 2010-2050



After comparing the different indicators, it is difficult to rank the different scenarios because they all have advantages and drawbacks:

Scenario 2 “EU goes ahead”

- Scenario 2 has the worst global RE performance caused by trade between taxed and non taxed regions. Both imports and exports are much higher in Scenario 2. Households will import from regions without carbon tax. Sectors will export more to regions without additional resource taxes charged on consumers.
- This scenario also has the best economic performance due to positive effect on exports and household consumption. This is due to the tax reclycling of the carbon tax and RMC based tax. The tax is recycled through lower labour costs. Households will earn more by paying less labour taxes and sectors pay less labour costs making labour more attractive compared to capital. Demand for labour will increase leading to higher wages.

Scenario 1 “Global cooperation”

- Global resource efficiency performance is much better compared to Scenario 2 where only EU implements all the measures. With global cooperation carbon leakage etc. does not occur though trade.
- Economic performance is a bit less compared to Scenario 2. But this is relatively small compared to the large resource efficiency improvement.

Scenario 3 “Civil society leads”

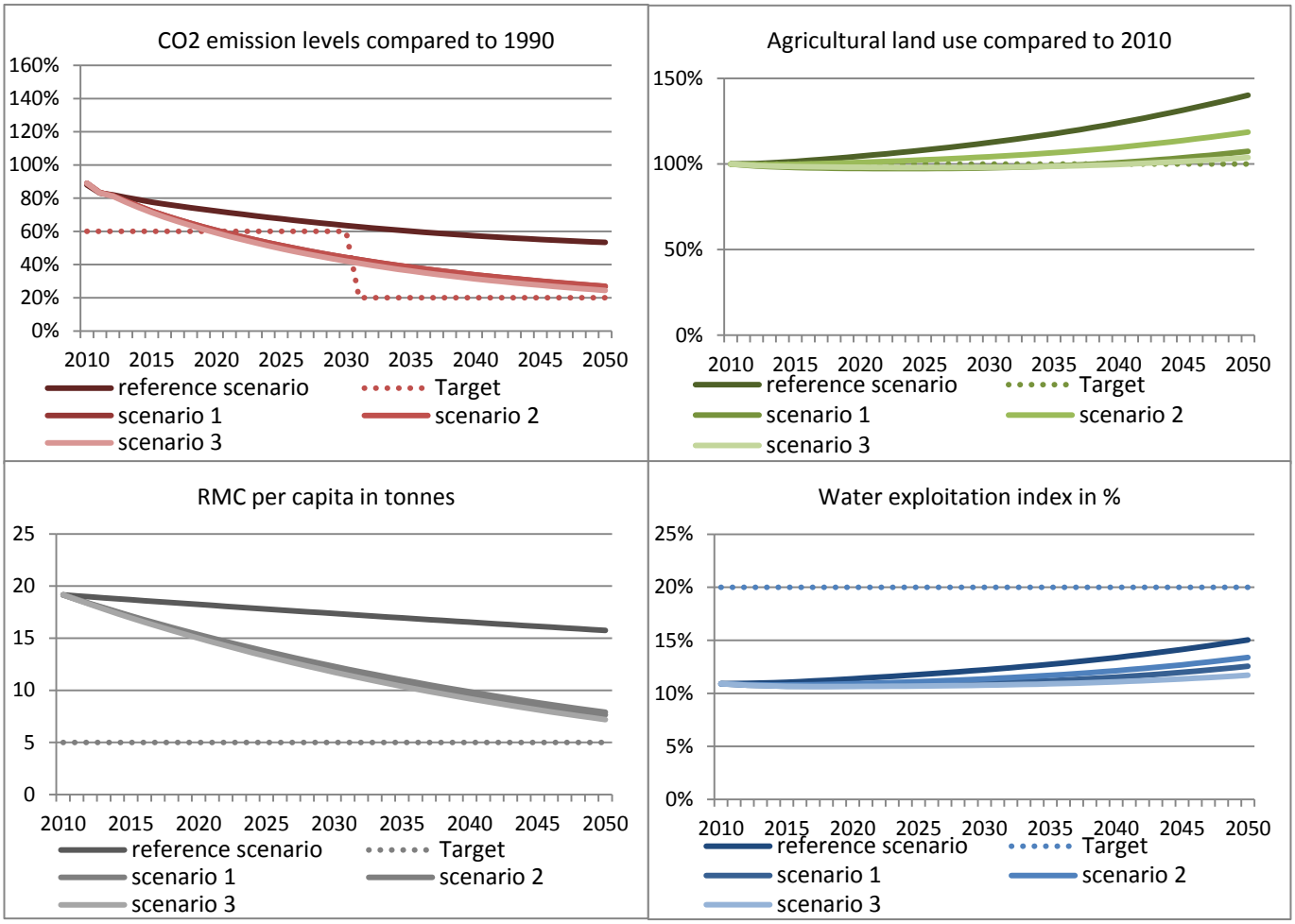
- This scenario has the best global resource efficiency performance (only CO2 performance is similar to SC2).
- However this goes together with very high economic costs, especially for EU.

Scenario 1 has the best balance between resource efficiency and economic performance. However it is difficult to implement these policies at the global level. Scenario 2 is more realistic in terms of policy implementation but the full potential of the measures on RE is not reached due to trade. However, households will benefit the most from ETR in this scenario. In Scenario 1 ETR is smaller in size because there are less resource taxes and in Scenario 3 the positive ETR effect is offset by reduced working week and reduced final consumption.

One important result of this study is that it is very difficult to find policy scenarios able to meet all four targets (see Figure 5.3). Here the target are met by introducing additional resource efficiency improvements. One could argue that this would be the result of policy measure called “EU innovation funding” as defined in Task 3.2. Such a measure would stimulate innovation and should lead to further technical progress in resource efficiency. In our reference scenario we have an annual raw material productivity improvement of two percent. To nearly meet the target of five tonnes per capita we had to assume an annual improvement of 2.7 percent instead (0.7% additional technical progress). For CO2 emissions we would need to assume an annual improvement of two percent instead of the 0.5 percent from our reference scenario (1.5 percent additional technical progress). For land use we would need to assume 1.1 percent instead of 0.7 percent from our reference scenario (0.4 percent additional progress). Another way to meet all targets simultaneously would be to implement a scenario that lead to an even lower GDP than in Scenario 3.

The reason why the targets are not reached without additional technical progress or a lower economic welfare is that these targets are actually competing. Meeting the CO2 target alone is possible with a tax on carbon. But because of substitutions and the change in consumption habits, this leads to an increase in raw material intensive products. Such a rebound effect leads to trade-off between instruments and conflicting targets: reducing CO2 versus reducing RMC. Interestingly though this research shows also that there can also be synergy between targets. Here it only happen with land and water.

Figure 5.3: Resource efficiency indicators and targets (dashed lines) in the EU-27 by scenario, 2010-2050



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Annex A: Implementation of policy measures into EXIOMOD 2.0

The technical implementation of each policy measure is explained in the table below. The colors indicate on which resource efficiency target, the measure has the largest effect on. Red represents CO2 emissions, grey stands for material use, green stands for land use and finally blue represents water use.

Table A1: Technical implementation of policy measures into EXIOMOD 2.0

	Scenario 1 "Global Cooperation"	**Scenario 2 "EU goes alone"**	**Scenario 3 "Civil Society Leads"**	**How the change is implemented in the model**
	Everything but hard market interventions	Extensive use of economic instruments	Civil society leads	
General policies				
Environmental tax reform	EU and non EU	EU		The carbon, water and resource taxes in are recycled back as a labour cost reduction. Half is used for a reduction in employer's social contributions and the other half benefits the households.
Border tax adjustment		EU		The taxes paid by industries were partly paid back to the industries, see Environmental Tax Reform. Also most taxes were charged on final consumption which does not affect competitiveness.
Public debt restrictions				In EXIOMOD government automatically adjust their spending to avoid debts.
Energy				
Extraction tax fossil fuels	EU and non EU			A tax on fossil fuel extraction paid by the industry, of 65 EUR per tonne.
Quota for total renewables and investment in grids	EU and non EU 90%	EU 90% Non EU 70%	EU 90% Non EU 70%	Co-production coefficients of electricity in the supply table are adjusted resulting in more electricity production from the renewable energy sector. In the EU 90% of the electricity is supplied by the renewable energy sector.
CCS	EU and non EU	EU and non EU	EU and non EU	Additional assumptions and data would be needed to implement CCS in EXIOMOD.
Reformed ETS (higher carbon price)		EU	EU	An additional carbon tax is introduced in the ETS sectors. We also implement a carbon tax in non EU countries, to represent their ETS systems.
Carbon tax for non ETS sectors (tax recycling)		EU	EU	A carbon tax is introduced for non ETS sectors and final consumers. The carbon tax is 75 EUR/ tonne CO2.
Mobility				
CO2 intensity standards for new cars and regulations e-mobility in cities	EU and non EU	EU and non EU	EU and non EU	The technical coefficients for the road transport sector are adjusted to have the energy mix of 80% electricity, 10% biomass and 10% fossil fuel. Household demand for energy products is adjusted to achieve the shift in energy use (via reduction of subsistence level of consumption in LES-CES utility function).
Autonomous substitution of personal to public transport			EU	Reduction in household demand for petroleum products and increase in household demand for road and rail transport services, both by 30%.
Autonomous reduction of transport use by households			EU	Reduction in household demand for petroleum products and road and rail transport services, both by 10%.
Subsidies public transport	EU and non EU	EU and non EU	EU and non EU	By introducing a subsidy for public transport, overall transport demand increased as a result. Therefore we modeled this via an increase in household demand for public transport and a reduction in household energy use.
Buildings				

Subsidies 3% renovation rate concerning energy efficiency	EU and non EU	EU		Reduction of 43% in household demand for heating.
Rising willingness to share a house			EU	Reduction of 50% in household demand for heating. This is assumed for 20% of the households.
Industry				
Extraction tax metals	EU and non EU			A tax on metal extraction paid by the industry, of 65 EUR per tonne.
Recycling quota for metals, non-metallic minerals and paper	EU and non EU	EU and non EU	EU and non EU	The technical coefficients are adjusted for the manufacturing of metals, non-metallic minerals and paper. Less input is needed from the mining or forestry sector and more input is needed from the own sector. Recycled content of respectively 70%, 85% and 85% is reached.
RMC based tax on final demand metals and non-metallic minerals		EU		An RMC based tax requires a lot of computation power, because it requires calculating footprints using an input-output model. Every year the footprints change. We therefore choose to implement the tax at the extraction level to achieve the same effect. To avoid loss in EU-27 competitiveness we implement this globally. Again this has the same effect as an RMC based tax, because in both cases EU-27 imports less materials from non EU-27 regions. A tax on material extraction paid by the industry globally, of 65 EUR per tonne.
Mandatory eco-design standards for reuse and repairability	EU and non EU		EU and non EU	Reduction in household demand for durables by 75%. Increase in household demand for repair services by 100%.
Tax on water withdrawal		EU		A tax on water withdrawal paid by the industry, of 0.50 EUR per m3.
Tax on collected and purified water		EU		This measure is not needed in EXIOMOD, because the water target is already achieved in the reference scenario.
Innovation funding	EU	EU	EU	In each scenario this measure is used to fill the gap to meet the resource efficiency targets. The innovation funding leads to technological progress in terms of resource efficiency.
Consumption				
Autonomous reduction consumption environmentally harmful commodities			EU	To identify the environmentally harmful commodities we would have to calculate footprints for each product each year. This requires a lot of computational power. To achieve the same effect we can implement this in the same way as the RMC based tax.
Reduction total consumption			EU	Increase in saving rate of households with 15 percent point.
Labour market				
Autonomous reduction of work week			EU	Reduction in total labour supply by 20%.
Food, agriculture, forests				
Reduction of food waste by consumers	EU and non EU		EU	Reduction in household demand for food by 33%.
Reduction of food waste by producers	EU and non EU	EU		The technical coefficients are adjusted for the manufacturing of food. Less input by 10% is needed from the agricultural sectors and more input is needed from the own sector.
Tax on meat consumption	EU and non EU	EU		Tax on meat products for households of 50%.

Autonomous reduction of meat consumption			EU	Reduction in household demand for meat products by 50%.
Regulation agricultural land use expansion	EU and non EU	EU and non EU		
Regulation water agriculture (20%)	EU and non EU	EU and non EU		This measure is not needed in EXIOMOD, because the water target is already achieved in the reference scenario.

Annex B: List of regions and sectors

List of regions		
Austria	Italy	United States
Belgium	Luxembourg	Japan
Czech Republic	Netherlands	China
Germany	Poland	Rest of the world
Denmark	Portugal	
Estonia	Romania	
Spain	Sweden	
Finland	Slovenia	
France	Slovakia	
Greece	United Kingdom	
Hungary	Cyprus, Malta, Lithuania, Bulgaria and Latvia as one region	
Ireland		

List of sectors
Paddy rice
Wheat
Cereal grains nec
Vegetables, fruit, nuts
Oil seeds
Sugar cane, sugar beet
Crops nec
Animal production
Forestry and logging
Fishing and aquaculture
Mining fossil fuels
Mining of metal ores and non-metallic minerals
Manufacturing of food, beverage and tobacco products
Manufacturing of textile, wood and printed products (ETS sector)
Manufacturing of coke products (ETS sector)
Manufacturing of refined petroleum products (ETS sector)
Manufacturing of chemicals and chemical products (ETS sector)
Manufacturing of rubber and plastic products
Manufacturing of non-metallic mineral products (ETS sector)
Manufacturing of basic metals and metal products (ETS sector)
Manufacturing of electronic computer, optical and electrical equipment
Manufacturing of machinery and equipment nec and other manufacturing
Electricity grey (ETS sector)
Electricity green (ETS sector)

Transmission and distribution services
Steam and hot water supply services
Collected and purified water, distribution services of water
Construction
Wholesale and retail trade
Accomodation and food service activities
Railway transportation services
Other land transportation services
Other transportation services
Real estate, renting and business activities
Public administration, education, health and other activities
Waste for treatment

Annex C: EU-27 Member States tables

EU-27	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	12,408	21,391	1.4%	21,261	21,322	18,793	-0.6%	-0.3%	-12.1%
Disposable income of households	9,601	16,210	1.3%	16,135	16,074	14,240	-0.5%	-0.8%	-12.1%
Household consumption	6,207	11,322	1.5%	11,446	11,423	8,388	1.1%	0.9%	-25.9%
Public consumption	2,667	4,808	1.5%	4,706	4,765	4,038	-2.1%	-0.9%	-16.0%
Investments	2,450	4,127	1.3%	4,072	4,059	5,445	-1.3%	-1.6%	31.9%
Exports	1,770	3,700	1.9%	3,687	3,780	3,530	-0.3%	2.2%	-4.6%
Imports	1,448	3,930	2.5%	4,010	4,155	3,913	2.0%	5.7%	-0.4%
Social indicators									
Employment in bln EUR	6,234	5,706	-0.2%	5,706	5,706	4,565	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	51%	51%		50%	50%	50%			
Share of household expenditure for basic goods**	34%	16%		16%	16%	22%			
Environmental indicators									
CO2 emissions in Mt	3,885	2,355	-1.2%	1,183	1,190	1,079	-50%	-49%	-54%
Raw material consumption (RMC) in tonnes per capita	19.2	15.8	-0.5%	7.6	7.9	7.2	-51%	-50%	-54%
Biomass	3.4	2.5	-0.8%	1.8	1.9	1.4	-28%	-21%	-43%
Wood	0.7	0.7	-0.2%	0.5	0.5	0.4	-20%	-22%	-33%
Metal ores	1.3	1.4	0.2%	0.8	0.8	0.8	-43%	-42%	-42%
Non-metallic minerals	9.8	9.3	-0.1%	3.5	3.4	3.5	-63%	-63%	-62%
Fossil fuels	3.9	1.9	-1.7%	1.1	1.2	1.0	-44%	-38%	-49%
Raw material productivity (GDP/RMC in EUR per kg)	1.3	2.7		5.4	5.3	5.1			
Ecosystem services									
Water exploitation index (WEI)	11%	15%		13%	13%	12%			
Total domestic harvest of crops in bln EUR	219	343	1.1%	287	329	281	-16.3%	-4.2%	-18.1%
Average domestic crop production price	1.01	1.08	0.2%	1.08	1.08	1.11	-0.1%	-0.1%	2.8%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

Austria	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	273	423	1.1%	421	421	372	-0.6%	-0.5%	-12.1%
Disposable income of households	200	318	1.2%	316	315	279	-0.5%	-0.7%	-12.1%
Household consumption	125	205	1.3%	207	208	152	1.0%	1.3%	-26.1%
Public consumption	56	91	1.2%	90	91	75	-1.3%	0.4%	-17.4%
Investments	56	97	1.4%	96	95	119	-1.8%	-2.4%	21.9%
Exports	145	222	1.1%	219	223	209	-1.6%	0.3%	-5.9%
Imports	122	211	1.4%	208	214	198	-1.6%	1.6%	-6.3%
Social indicators									
Employment in bln EUR	134	113	-0.4%	113	113	90	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	50%	53%		52%	52%	52%			
Share of household expenditure for basic goods**	34%	17%		17%	17%	23%			
Environmental indicators									
CO2 emissions in Mt	72	43	-1.3%	23	22	21	-48%	-50%	-51%
Raw material consumption (RMC) in tonnes per capita	26.0	19.5	-0.7%	10.5	10.6	9.9	-46%	-45%	-49%
Biomass	3.8	2.6	-0.9%	1.9	2.1	1.5	-28%	-21%	-41%
Wood	1.1	0.9	-0.5%	0.7	0.7	0.6	-21%	-22%	-31%
Metal ores	2.0	1.8	-0.3%	1.0	1.0	1.0	-45%	-44%	-45%
Non-metallic minerals	15.2	12.3	-0.5%	5.7	5.7	5.7	-53%	-54%	-53%
Fossil fuels	4.0	1.9	-1.8%	1.1	1.2	1.0	-40%	-35%	-45%
Raw material productivity (GDP/RMC in EUR per kg)	1.3	2.6		4.8	4.7	4.5			
Ecosystem services									
Water exploitation index (WEI)	4%	5%		5%	5%	5%			
Total domestic harvest of crops in bln EUR	3	5	0.9%	4	5	4	-14.1%	0.6%	-9.9%
Average domestic crop production price	1.02	1.03	0.0%	1.02	1.02	1.02	-0.3%	-0.4%	-0.2%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

Belgium	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	344	522	1.0%	520	521	459	-0.5%	-0.3%	-12.2%
Disposable income of households	241	373	1.1%	373	372	331	0.0%	-0.1%	-11.3%
Household consumption	151	239	1.2%	243	243	179	1.4%	1.6%	-25.0%
Public consumption	79	134	1.3%	134	136	115	-0.1%	0.8%	-14.4%
Investments	66	112	1.3%	111	111	135	-1.0%	-1.4%	20.6%
Exports	238	340	0.9%	337	348	314	-0.8%	2.5%	-7.6%
Imports	209	331	1.2%	332	345	310	0.3%	4.1%	-6.3%
Social indicators									
Employment in bln EUR	171	165	-0.1%	165	165	132	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	51%	53%		53%	53%	54%			
Share of household expenditure for basic goods**	34%	20%		20%	20%	27%			
Environmental indicators									
CO2 emissions in Mt	113	61	-1.5%	32	33	29	-47%	-46%	-52%
Raw material consumption (RMC) in tonnes per capita	19.4	13.0	-1.0%	7.0	7.3	6.4	-46%	-44%	-51%
Biomass	3.8	2.6	-1.0%	1.9	2.1	1.5	-28%	-20%	-42%
Wood	0.8	0.6	-0.5%	0.5	0.5	0.4	-20%	-21%	-32%
Metal ores	1.7	1.5	-0.4%	0.8	0.8	0.8	-45%	-44%	-45%
Non-metallic minerals	8.8	6.6	-0.7%	2.8	2.8	2.7	-58%	-58%	-59%
Fossil fuels	4.3	1.8	-2.2%	1.1	1.2	0.9	-40%	-34%	-46%
Raw material productivity (GDP/RMC in EUR per kg)	1.7	3.5		6.4	6.2	6.2			
Ecosystem services									
Water exploitation index (WEI)	32%	30%		23%	24%	22%			
Total domestic harvest of crops in bln EUR	3	3	0.6%	3	3	3	-18.9%	-8.2%	-10.9%
Average domestic crop production price	1.01	1.12	0.2%	1.12	1.12	1.20	0.3%	0.3%	6.8%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

Czech Republic	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	133	372	2.6%	368	370	330	-1.1%	-0.6%	-11.4%
Disposable income of households	94	237	2.3%	231	233	207	-2.5%	-1.7%	-12.6%
Household consumption	54	184	3.1%	184	185	136	0.0%	0.3%	-26.2%
Public consumption	27	69	2.4%	67	68	59	-2.6%	-1.4%	-15.0%
Investments	32	82	2.4%	79	79	101	-3.8%	-3.7%	23.2%
Exports	100	234	2.2%	231	241	221	-1.1%	3.0%	-5.4%
Imports	87	212	2.2%	207	218	199	-2.3%	2.6%	-6.3%
Social indicators									
Employment in bln EUR	55	46	-0.4%	46	46	37	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	43%	40%		39%	39%	39%			
Share of household expenditure for basic goods**	32%	7%		7%	7%	10%			
Environmental indicators									
CO2 emissions in Mt	113	87	-0.6%	40	43	37	-53%	-50%	-57%
Raw material consumption (RMC) in tonnes per capita	15.7	19.2	0.5%	9.5	9.7	8.9	-51%	-49%	-54%
Biomass	2.5	2.5	-0.1%	1.7	1.9	1.4	-30%	-22%	-44%
Wood	0.6	0.8	0.9%	0.6	0.6	0.5	-21%	-22%	-33%
Metal ores	0.9	1.4	1.2%	0.9	0.9	0.9	-36%	-33%	-33%
Non-metallic minerals	8.0	11.7	1.0%	4.6	4.5	4.6	-60%	-61%	-61%
Fossil fuels	3.8	2.9	-0.7%	1.6	1.8	1.4	-45%	-39%	-51%
Raw material productivity (GDP/RMC in EUR per kg)	0.8	1.8		3.6	3.6	3.5			
Ecosystem services									
Water exploitation index (WEI)	12%	19%		17%	18%	15%			
Total domestic harvest of crops in bln EUR	3	6	1.7%	5	6	4	-8.4%	0.6%	-19.6%
Average domestic crop production price	1.01	1.14	0.3%	1.14	1.14	1.24	-0.6%	-0.3%	8.2%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

Germany	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	2,432	3,179	0.7%	3,162	3,170	2,792	-0.5%	-0.3%	-12.2%
Disposable income of households	1,770	2,431	0.8%	2,407	2,425	2,121	-1.0%	-0.3%	-12.8%
Household consumption	1,203	1,688	0.9%	1,697	1,707	1,254	0.5%	1.1%	-25.7%
Public consumption	470	672	0.9%	656	665	568	-2.3%	-1.0%	-15.4%
Investments	421	619	1.0%	611	611	785	-1.3%	-1.2%	26.8%
Exports	1,093	1,581	0.9%	1,576	1,646	1,486	-0.3%	4.1%	-6.0%
Imports	884	1,570	1.4%	1,559	1,655	1,470	-0.7%	5.5%	-6.4%
Social indicators									
Employment in bln EUR	1,191	853	-0.8%	853	853	683	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	51%	55%		54%	54%	54%			
Share of household expenditure for basic goods**	34%	16%		16%	16%	22%			
Environmental indicators									
CO2 emissions in Mt	823	377	-1.9%	190	191	171	-50%	-49%	-55%
Raw material consumption (RMC) in tonnes per capita	21.3	16.4	-0.6%	7.9	8.2	7.3	-52%	-50%	-55%
Biomass	3.6	2.5	-1.0%	1.8	2.0	1.5	-28%	-20%	-40%
Wood	0.9	0.8	-0.4%	0.6	0.6	0.5	-21%	-22%	-34%
Metal ores	1.5	1.5	0.1%	0.8	0.9	0.8	-45%	-42%	-44%
Non-metallic minerals	9.9	9.3	-0.2%	3.3	3.3	3.2	-65%	-65%	-65%
Fossil fuels	5.3	2.4	-2.0%	1.4	1.5	1.3	-41%	-34%	-46%
Raw material productivity (GDP/RMC in EUR per kg)	1.4	2.6		5.4	5.2	5.1			
Ecosystem services									
Water exploitation index (WEI)	18%	14%		11%	12%	11%			
Total domestic harvest of crops in bln EUR	20	18	-0.3%	15	17	16	-16.0%	-7.1%	-10.2%
Average domestic crop production price	1.02	1.15	0.3%	1.15	1.16	1.21	0.3%	0.6%	5.6%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

Denmark	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	221	332	1.0%	329	330	286	-1.0%	-0.7%	-13.9%
Disposable income of households	151	246	1.2%	244	240	214	-0.9%	-2.3%	-12.9%
Household consumption	91	134	1.0%	137	135	107	1.8%	0.5%	-20.6%
Public consumption	57	111	1.7%	109	110	90	-1.6%	-1.0%	-18.5%
Investments	42	64	1.1%	64	63	72	0.1%	-2.5%	12.7%
Exports	106	163	1.1%	158	164	147	-3.0%	0.5%	-10.0%
Imports	97	169	1.4%	166	169	156	-1.9%	0.2%	-7.9%
Social indicators									
Employment in bln EUR	126	124	0.0%	124	124	99	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	60%	66%		65%	65%	66%			
Share of household expenditure for basic goods**	34%	21%		21%	21%	27%			
Environmental indicators									
CO2 emissions in Mt	50	18	-2.6%	10	8	8	-42%	-54%	-54%
Raw material consumption (RMC) in tonnes per capita	26.1	18.2	-0.9%	8.3	8.5	7.5	-54%	-53%	-59%
Biomass	4.7	3.2	-0.9%	2.3	2.5	1.8	-28%	-22%	-42%
Wood	1.1	0.9	-0.6%	0.7	0.7	0.6	-19%	-23%	-28%
Metal ores	1.6	1.5	-0.2%	0.9	0.9	0.8	-43%	-44%	-45%
Non-metallic minerals	13.5	10.4	-0.6%	3.2	3.1	3.0	-69%	-70%	-71%
Fossil fuels	5.1	2.2	-2.1%	1.3	1.4	1.2	-42%	-36%	-46%
Raw material productivity (GDP/RMC in EUR per kg)	1.5	3.1		6.7	6.5	6.4			
Ecosystem services									
Water exploitation index (WEI)	4%	5%		4%	5%	5%			
Total domestic harvest of crops in bln EUR	3	4	0.9%	3	4	3	-19.7%	-6.7%	-16.1%
Average domestic crop production price	1.02	1.16	0.3%	1.17	1.16	1.24	0.7%	0.1%	6.7%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

Estonia	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	15	71	4.0%	71	71	62	-0.8%	-0.8%	-12.3%
Disposable income of households	11	45	3.5%	44	44	39	-1.4%	-1.8%	-12.6%
Household consumption	7	40	4.6%	40	40	30	0.6%	-0.3%	-25.6%
Public consumption	3	10	3.4%	9	10	8	-2.5%	0.8%	-16.3%
Investments	5	14	2.5%	13	13	18	-4.2%	-5.4%	27.7%
Exports	9	34	3.5%	34	35	32	-0.3%	2.0%	-6.6%
Imports	9	31	3.0%	30	31	29	-1.4%	1.0%	-7.2%
Social indicators									
Employment in bln EUR	7	6	-0.5%	6	6	5	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	50%	42%		41%	41%	41%			
Share of household expenditure for basic goods**	36%	5%		5%	5%	6%			
Environmental indicators									
CO2 emissions in Mt	19	16	-0.5%	7	7	6	-57%	-58%	-61%
Raw material consumption (RMC) in tonnes per capita	23.3	37.4	1.2%	18.4	19.4	17.8	-51%	-48%	-52%
Biomass	2.8	4.0	0.9%	2.9	3.1	2.2	-29%	-23%	-45%
Wood	1.0	2.0	1.7%	1.6	1.6	1.4	-22%	-23%	-33%
Metal ores	1.1	2.2	1.8%	1.3	1.3	1.3	-44%	-43%	-43%
Non-metallic minerals	12.5	22.5	1.5%	9.9	9.7	10.6	-56%	-57%	-53%
Fossil fuels	5.9	6.6	0.3%	2.7	3.8	2.4	-58%	-43%	-63%
Raw material productivity (GDP/RMC in EUR per kg)	0.5	1.5		3.1	3.0	2.8			
Ecosystem services									
Water exploitation index (WEI)	14%	34%		24%	25%	24%			
Total domestic harvest of crops in bln EUR	0	2	4.2%	2	2	2	-10.4%	0.8%	-2.2%
Average domestic crop production price	1.01	0.86	-0.4%	0.85	0.84	0.89	-1.3%	-1.8%	3.8%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

Spain	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	1,056	2,097	1.7%	2,085	2,091	1,847	-0.6%	-0.3%	-11.9%
Disposable income of households	927	1,727	1.6%	1,727	1,722	1,532	0.0%	-0.3%	-11.3%
Household consumption	536	1,175	2.0%	1,187	1,185	848	1.1%	0.9%	-27.8%
Public consumption	200	423	1.9%	413	418	353	-2.6%	-1.2%	-16.5%
Investments	302	448	1.0%	442	441	613	-1.3%	-1.7%	36.7%
Exports	273	524	1.6%	509	538	480	-2.8%	2.8%	-8.4%
Imports	318	573	1.5%	560	591	536	-2.3%	3.1%	-6.6%
Social indicators									
Employment in bln EUR	528	463	-0.3%	463	463	370	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	49%	48%		48%	48%	49%			
Share of household expenditure for basic goods**	36%	14%		14%	14%	19%			
Environmental indicators									
CO2 emissions in Mt	280	185	-1.0%	92	92	86	-50%	-50%	-53%
Raw material consumption (RMC) in tonnes per capita	21.6	15.4	-0.8%	7.4	7.5	7.3	-52%	-51%	-53%
Biomass	3.3	2.3	-0.9%	1.6	1.8	1.3	-28%	-22%	-44%
Wood	0.5	0.5	-0.3%	0.4	0.4	0.3	-20%	-22%	-34%
Metal ores	1.2	1.1	-0.2%	0.7	0.7	0.7	-40%	-37%	-36%
Non-metallic minerals	13.6	10.2	-0.7%	4.0	3.9	4.3	-61%	-62%	-58%
Fossil fuels	3.0	1.4	-1.9%	0.8	0.8	0.7	-45%	-40%	-50%
Raw material productivity (GDP/RMC in EUR per kg)	1.1	2.7		5.5	5.4	4.9			
Ecosystem services									
Water exploitation index (WEI)	30%	45%		38%	41%	35%			
Total domestic harvest of crops in bln EUR	30	53	1.5%	44	50	42	-17.1%	-5.2%	-19.8%
Average domestic crop production price	1.02	1.04	0.0%	1.03	1.04	1.02	-0.7%	0.1%	-1.6%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

Finland	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	178	295	1.3%	295	296	261	-0.1%	0.4%	-11.7%
Disposable income of households	128	226	1.4%	225	224	201	-0.7%	-1.2%	-11.3%
Household consumption	74	135	1.5%	137	136	101	1.4%	0.9%	-24.9%
Public consumption	41	72	1.4%	71	72	60	-1.7%	0.2%	-17.3%
Investments	34	63	1.5%	61	61	76	-1.8%	-2.4%	21.2%
Exports	79	141	1.5%	144	148	137	2.1%	5.0%	-3.3%
Imports	64	139	1.9%	141	146	134	1.5%	4.9%	-3.8%
Social indicators									
Employment in bln EUR	86	79	-0.2%	79	79	63	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	50%	56%		55%	55%	56%			
Share of household expenditure for basic goods**	34%	17%		16%	16%	22%			
Environmental indicators									
CO2 emissions in Mt	64	30	-1.9%	16	16	15	-47%	-46%	-51%
Raw material consumption (RMC) in tonnes per capita	34.3	25.8	-0.7%	12.3	12.4	11.6	-52%	-52%	-55%
Biomass	3.5	2.8	-0.6%	2.1	2.2	1.7	-26%	-20%	-40%
Wood	2.7	2.0	-0.8%	1.6	1.5	1.4	-21%	-22%	-29%
Metal ores	3.6	3.0	-0.5%	1.8	1.8	1.8	-41%	-41%	-40%
Non-metallic minerals	20.4	16.0	-0.6%	5.7	5.5	5.6	-65%	-65%	-65%
Fossil fuels	4.0	2.1	-1.6%	1.2	1.4	1.1	-41%	-34%	-46%
Raw material productivity (GDP/RMC in EUR per kg)	1.0	2.0		4.3	4.2	4.0			
Ecosystem services									
Water exploitation index (WEI)	2%	3%		3%	3%	3%			
Total domestic harvest of crops in bln EUR	2	3	1.2%	2	3	3	-16.0%	-4.2%	2.6%
Average domestic crop production price	1.01	1.00	0.0%	1.00	1.00	1.00	0.4%	0.5%	0.3%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

France	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	1,902	3,236	1.3%	3,214	3,226	2,821	-0.7%	-0.3%	-12.8%
Disposable income of households	1,623	2,648	1.2%	2,636	2,625	2,304	-0.5%	-0.9%	-13.0%
Household consumption	953	1,676	1.4%	1,695	1,690	1,184	1.2%	0.9%	-29.3%
Public consumption	460	797	1.4%	777	789	675	-2.6%	-1.1%	-15.4%
Investments	380	641	1.3%	634	633	877	-1.2%	-1.3%	36.7%
Exports	478	837	1.4%	819	868	760	-2.1%	3.8%	-9.2%
Imports	485	886	1.5%	869	923	821	-1.8%	4.2%	-7.3%
Social indicators									
Employment in bln EUR	991	1,053	0.2%	1,053	1,053	843	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	54%	52%		52%	52%	52%			
Share of household expenditure for basic goods**	34%	20%		20%	20%	28%			
Environmental indicators									
CO2 emissions in Mt	387	246	-1.1%	123	129	114	-50%	-48%	-54%
Raw material consumption (RMC) in tonnes per capita	19.7	13.1	-1.0%	6.6	7.0	6.4	-49%	-47%	-51%
Biomass	4.5	2.5	-1.4%	1.8	2.0	1.4	-30%	-22%	-44%
Wood	0.7	0.5	-0.7%	0.4	0.4	0.4	-21%	-22%	-34%
Metal ores	1.0	0.9	-0.2%	0.5	0.5	0.5	-46%	-44%	-47%
Non-metallic minerals	9.6	7.6	-0.6%	3.0	3.0	3.3	-60%	-60%	-56%
Fossil fuels	3.8	1.5	-2.3%	0.9	1.0	0.8	-41%	-33%	-47%
Raw material productivity (GDP/RMC in EUR per kg)	1.5	3.4		6.7	6.4	6.1			
Ecosystem services									
Water exploitation index (WEI)	17%	18%		15%	16%	14%			
Total domestic harvest of crops in bln EUR	50	64	0.6%	52	61	53	-18.1%	-3.6%	-16.4%
Average domestic crop production price	1.01	1.16	0.3%	1.16	1.17	1.16	0.1%	0.3%	-0.1%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

Greece	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	226	539	2.2%	537	539	492	-0.5%	-0.1%	-8.8%
Disposable income of households	171	371	2.0%	367	362	329	-1.1%	-2.4%	-11.4%
Household consumption	142	336	2.2%	340	336	263	1.1%	0.1%	-21.6%
Public consumption	42	90	2.0%	87	89	76	-3.5%	-1.1%	-15.5%
Investments	45	92	1.8%	89	88	129	-3.1%	-3.9%	41.0%
Exports	47	131	2.6%	129	134	134	-1.6%	1.9%	2.4%
Imports	67	142	1.9%	137	141	138	-3.3%	-0.7%	-2.7%
Social indicators									
Employment in bln EUR	81	67	-0.4%	67	67	54	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	38%	35%		35%	34%	34%			
Share of household expenditure for basic goods**	34%	12%		12%	12%	15%			
Environmental indicators									
CO2 emissions in Mt	102	85	-0.4%	50	41	41	-41%	-52%	-53%
Raw material consumption (RMC) in tonnes per capita	23.5	19.6	-0.5%	8.2	8.5	8.5	-58%	-57%	-56%
Biomass	3.5	2.6	-0.7%	1.8	2.0	1.5	-30%	-24%	-43%
Wood	0.6	0.7	0.4%	0.5	0.5	0.4	-23%	-26%	-35%
Metal ores	1.5	1.8	0.5%	1.2	1.2	1.5	-34%	-33%	-19%
Non-metallic minerals	10.9	11.3	0.1%	3.5	3.4	4.0	-69%	-70%	-65%
Fossil fuels	7.0	3.1	-2.0%	1.1	1.3	1.1	-64%	-57%	-64%
Raw material productivity (GDP/RMC in EUR per kg)	0.8	2.4		5.7	5.5	5.0			
Ecosystem services									
Water exploitation index (WEI)	13%	21%		18%	21%	18%			
Total domestic harvest of crops in bln EUR	9	15	1.3%	12	15	12	-17.6%	1.1%	-16.3%
Average domestic crop production price	1.00	1.03	0.1%	1.03	1.03	1.02	0.0%	-0.5%	-0.8%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

Hungary	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	99	259	2.4%	257	258	229	-0.8%	-0.4%	-11.8%
Disposable income of households	69	167	2.2%	167	166	148	-0.3%	-0.8%	-11.9%
Household consumption	44	131	2.8%	133	132	98	1.7%	0.7%	-25.2%
Public consumption	22	57	2.4%	56	57	49	-2.6%	0.0%	-14.3%
Investments	20	45	2.1%	44	43	59	-2.8%	-3.9%	31.7%
Exports	75	181	2.2%	177	184	172	-2.1%	1.7%	-4.6%
Imports	71	170	2.2%	166	173	163	-2.0%	1.9%	-4.2%
Social indicators									
Employment in bln EUR	46	37	-0.6%	37	37	29	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	49%	46%		46%	45%	45%			
Share of household expenditure for basic goods**	33%	8%		8%	8%	11%			
Environmental indicators									
CO2 emissions in Mt	52	42	-0.5%	22	21	20	-49%	-50%	-53%
Raw material consumption (RMC) in tonnes per capita	11.2	13.8	0.5%	7.0	7.1	6.7	-49%	-49%	-51%
Biomass	2.2	2.1	-0.1%	1.5	1.6	1.2	-27%	-22%	-39%
Wood	0.4	0.5	0.9%	0.4	0.4	0.4	-19%	-22%	-31%
Metal ores	0.6	1.0	1.2%	0.6	0.7	0.7	-34%	-32%	-30%
Non-metallic minerals	6.1	8.5	0.9%	3.3	3.2	3.5	-61%	-62%	-60%
Fossil fuels	2.0	1.7	-0.4%	1.1	1.2	1.0	-35%	-32%	-42%
Raw material productivity (GDP/RMC in EUR per kg)	0.9	2.0		4.0	3.9	3.7			
Ecosystem services									
Water exploitation index (WEI)	5%	10%		8%	8%	8%			
Total domestic harvest of crops in bln EUR	5	12	2.2%	10	11	10	-11.9%	-2.1%	-13.4%
Average domestic crop production price	1.02	0.97	-0.1%	0.97	0.96	1.00	0.3%	-0.5%	3.4%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

Ireland	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	179	370	1.8%	369	371	335	-0.2%	0.4%	-9.4%
Disposable income of households	141	286	1.8%	286	285	264	0.0%	-0.5%	-7.6%
Household consumption	71	176	2.3%	180	179	131	2.1%	1.7%	-25.6%
Public consumption	32	70	2.0%	68	70	58	-1.6%	0.6%	-16.1%
Investments	43	74	1.4%	72	72	94	-1.9%	-2.1%	28.0%
Exports	144	303	1.9%	314	321	305	3.4%	5.8%	0.5%
Imports	122	277	2.1%	287	296	276	3.8%	6.8%	-0.1%
Social indicators									
Employment in bln EUR	81	97	0.4%	97	97	78	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	44%	46%		45%	44%	46%			
Share of household expenditure for basic goods**	38%	17%		17%	17%	23%			
Environmental indicators									
CO2 emissions in Mt	44	34	-0.6%	18	17	16	-49%	-50%	-54%
Raw material consumption (RMC) in tonnes per capita	40.4	26.4	-1.1%	13.3	13.3	13.1	-50%	-50%	-50%
Biomass	5.6	3.9	-0.9%	2.9	3.2	2.3	-26%	-20%	-42%
Wood	0.6	0.5	-0.4%	0.4	0.4	0.4	-21%	-24%	-32%
Metal ores	1.9	1.7	-0.3%	1.0	1.0	1.0	-42%	-41%	-38%
Non-metallic minerals	27.3	18.0	-1.0%	7.8	7.4	8.3	-57%	-59%	-54%
Fossil fuels	5.0	2.2	-2.0%	1.2	1.4	1.2	-46%	-38%	-48%
Raw material productivity (GDP/RMC in EUR per kg)	1.0	2.3		4.6	4.6	4.2			
Ecosystem services									
Water exploitation index (WEI)	1%	3%		3%	3%	3%			
Total domestic harvest of crops in bln EUR	1	3	1.8%	2	2	2	-18.5%	-10.1%	-20.3%
Average domestic crop production price	1.02	1.11	0.2%	1.13	1.14	1.14	2.5%	3.1%	2.9%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

Italy	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	1,512	1,770	0.4%	1,750	1,756	1,527	-1.1%	-0.8%	-13.7%
Disposable income of households	984	1,227	0.6%	1,223	1,226	1,089	-0.4%	-0.1%	-11.3%
Household consumption	790	957	0.5%	967	969	760	1.1%	1.2%	-20.6%
Public consumption	296	407	0.8%	395	400	325	-3.1%	-1.8%	-20.3%
Investments	299	350	0.4%	347	346	419	-0.8%	-1.1%	19.6%
Exports	429	586	0.8%	572	597	528	-2.4%	1.9%	-9.9%
Imports	399	639	1.2%	632	665	597	-1.1%	4.1%	-6.6%
Social indicators									
Employment in bln EUR	785	605	-0.7%	605	605	484	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	51%	56%		55%	55%	57%			
Share of household expenditure for basic goods**	36%	22%		22%	22%	27%			
Environmental indicators									
CO2 emissions in Mt	436	177	-2.2%	86	88	79	-52%	-50%	-56%
Raw material consumption (RMC) in tonnes per capita	16.3	10.2	-1.2%	5.0	5.2	4.6	-51%	-49%	-55%
Biomass	2.6	1.6	-1.3%	1.1	1.3	0.9	-27%	-20%	-45%
Wood	0.5	0.4	-0.6%	0.3	0.3	0.3	-18%	-20%	-30%
Metal ores	1.0	0.9	-0.4%	0.5	0.5	0.5	-48%	-46%	-48%
Non-metallic minerals	8.9	6.1	-0.9%	2.4	2.4	2.3	-61%	-61%	-62%
Fossil fuels	3.2	1.2	-2.4%	0.7	0.7	0.6	-46%	-41%	-50%
Raw material productivity (GDP/RMC in EUR per kg)	1.5	2.9		5.9	5.7	5.6			
Ecosystem services									
Water exploitation index (WEI)	23%	18%		16%	17%	17%			
Total domestic harvest of crops in bln EUR	29	22	-0.6%	18	21	22	-17.6%	-3.3%	-1.6%
Average domestic crop production price	1.02	1.19	0.4%	1.19	1.19	1.25	-0.1%	0.0%	4.6%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

Netherlands	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	584	899	1.1%	894	898	794	-0.6%	-0.1%	-11.7%
Disposable income of households	420	653	1.1%	648	644	576	-0.6%	-1.3%	-11.7%
Household consumption	231	393	1.3%	400	399	282	1.8%	1.5%	-28.3%
Public consumption	150	244	1.2%	239	241	214	-2.1%	-1.6%	-12.5%
Investments	104	184	1.4%	184	184	231	0.0%	-0.3%	25.5%
Exports	325	500	1.1%	496	518	476	-0.8%	3.7%	-4.8%
Imports	258	475	1.5%	476	498	459	0.2%	4.8%	-3.4%
Social indicators									
Employment in bln EUR	287	257	-0.3%	257	257	206	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	50%	52%		52%	51%	52%			
Share of household expenditure for basic goods**	34%	17%		17%	17%	24%			
Environmental indicators									
CO2 emissions in Mt	181	97	-1.5%	51	52	46	-47%	-47%	-52%
Raw material consumption (RMC) in tonnes per capita	20.9	17.6	-0.4%	8.1	8.4	7.4	-54%	-52%	-58%
Biomass	3.6	2.7	-0.7%	2.0	2.2	1.6	-26%	-19%	-40%
Wood	0.8	0.7	-0.2%	0.6	0.5	0.5	-20%	-22%	-33%
Metal ores	1.7	1.8	0.1%	0.9	1.0	0.9	-48%	-47%	-48%
Non-metallic minerals	10.0	10.0	0.0%	3.3	3.2	3.1	-67%	-67%	-69%
Fossil fuels	4.8	2.4	-1.7%	1.3	1.5	1.2	-44%	-38%	-49%
Raw material productivity (GDP/RMC in EUR per kg)	1.7	3.0		6.4	6.2	6.3			
Ecosystem services									
Water exploitation index (WEI)	11%	10%		8%	8%	7%			
Total domestic harvest of crops in bln EUR	10	10	0.0%	8	9	9	-12.0%	-1.2%	-5.4%
Average domestic crop production price	1.02	1.20	0.4%	1.20	1.20	1.24	0.5%	0.4%	4.0%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

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Poland	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	345	1,120	3.0%	1,114	1,115	1,013	-0.6%	-0.5%	-9.6%
Disposable income of households	249	707	2.6%	696	702	625	-1.5%	-0.7%	-11.6%
Household consumption	182	632	3.2%	636	637	486	0.6%	0.7%	-23.1%
Public consumption	65	194	2.8%	193	197	170	-0.8%	1.1%	-12.6%
Investments	69	201	2.7%	196	195	274	-2.5%	-2.7%	36.6%
Exports	132	366	2.6%	356	363	350	-2.9%	-1.0%	-4.4%
Imports	129	329	2.4%	318	330	314	-3.4%	0.3%	-4.4%
Social indicators									
Employment in bln EUR	111	83	-0.7%	83	83	66	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	37%	34%		32%	33%	32%			
Share of household expenditure for basic goods**	30%	6%		6%	6%	8%			
Environmental indicators									
CO2 emissions in Mt	313	257	-0.5%	124	127	115	-52%	-51%	-55%
Raw material consumption (RMC) in tonnes per capita	14.1	18.2	0.6%	9.8	10.1	9.0	-46%	-44%	-50%
Biomass	2.7	2.7	0.0%	1.9	2.1	1.5	-30%	-23%	-43%
Wood	0.5	0.7	1.2%	0.6	0.6	0.5	-21%	-22%	-31%
Metal ores	1.4	2.1	1.1%	1.3	1.3	1.3	-39%	-39%	-40%
Non-metallic minerals	6.2	9.8	1.2%	4.4	4.4	4.3	-55%	-55%	-56%
Fossil fuels	3.5	2.9	-0.5%	1.6	1.8	1.4	-44%	-37%	-50%
Raw material productivity (GDP/RMC in EUR per kg)	0.6	1.8		3.3	3.1	3.2			
Ecosystem services									
Water exploitation index (WEI)	19%	37%		30%	32%	24%			
Total domestic harvest of crops in bln EUR	14	48	3.1%	38	42	30	-19.7%	-11.8%	-37.8%
Average domestic crop production price	1.00	0.98	0.0%	0.98	0.98	1.09	-0.6%	-0.9%	10.8%

Source: EXIOMOD 2.0
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Portugal	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	180	285	1.2%	281	283	246	-1.3%	-0.5%	-13.7%
Disposable income of households	123	194	1.2%	193	193	171	-0.7%	-0.8%	-12.2%
Household consumption	99	163	1.3%	165	165	126	1.2%	0.8%	-22.9%
Public consumption	40	62	1.1%	60	62	51	-3.5%	-0.8%	-17.6%
Investments	36	54	1.0%	53	53	68	-2.4%	-2.6%	25.4%
Exports	52	84	1.2%	80	85	75	-4.0%	1.7%	-10.8%
Imports	62	97	1.1%	94	99	88	-3.3%	2.1%	-9.0%
Social indicators									
Employment in bln EUR	90	67	-0.7%	67	67	54	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	53%	54%		54%	53%	55%			
Share of household expenditure for basic goods**	34%	15%		15%	15%	19%			
Environmental indicators									
CO2 emissions in Mt	51	29	-1.4%	14	14	13	-52%	-50%	-54%
Raw material consumption (RMC) in tonnes per capita	15.9	11.9	-0.7%	6.0	6.1	5.8	-50%	-49%	-52%
Biomass	2.6	1.8	-0.9%	1.3	1.4	1.0	-29%	-22%	-43%
Wood	0.5	0.4	-0.4%	0.3	0.3	0.3	-20%	-22%	-33%
Metal ores	0.7	0.8	0.1%	0.4	0.4	0.4	-43%	-41%	-41%
Non-metallic minerals	9.5	7.8	-0.5%	3.2	3.2	3.4	-58%	-59%	-56%
Fossil fuels	2.6	1.2	-1.9%	0.7	0.8	0.7	-42%	-37%	-46%
Raw material productivity (GDP/RMC in EUR per kg)	1.1	2.5		5.0	4.9	4.5			
Ecosystem services									
Water exploitation index (WEI)	15%	21%		17%	19%	19%			
Total domestic harvest of crops in bln EUR	4	6	0.9%	5	6	5	-18.6%	-3.2%	-14.5%
Average domestic crop production price	1.01	1.01	0.0%	1.00	1.01	0.97	-0.2%	0.3%	-3.7%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

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Romania	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	131	472	3.3%	471	471	428	-0.2%	-0.3%	-9.3%
Disposable income of households	113	321	2.6%	317	313	278	-1.3%	-2.3%	-13.2%
Household consumption	77	286	3.3%	287	284	211	0.3%	-0.6%	-26.2%
Public consumption	21	63	2.7%	61	62	51	-3.7%	-2.2%	-18.9%
Investments	37	90	2.2%	88	87	130	-2.2%	-2.9%	45.0%
Exports	37	134	3.3%	134	137	136	0.5%	2.8%	1.5%
Imports	50	122	2.3%	120	122	119	-1.9%	-0.4%	-2.9%
Social indicators									
Employment in bln EUR	46	35	-0.7%	35	35	28	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	40%	33%		32%	32%	31%			
Share of household expenditure for basic goods**	30%	6%		6%	6%	8%			
Environmental indicators									
CO2 emissions in Mt	77	82	0.2%	40	41	37	-51%	-50%	-55%
Raw material consumption (RMC) in tonnes per capita	13.9	19.5	0.9%	6.1	6.1	5.4	-69%	-69%	-72%
Biomass	2.1	2.3	0.2%	1.6	1.7	1.2	-28%	-24%	-49%
Wood	0.3	0.6	1.4%	0.5	0.4	0.4	-22%	-23%	-34%
Metal ores	0.5	1.0	1.7%	0.9	0.9	0.9	-15%	-14%	-12%
Non-metallic minerals	9.0	14.1	1.1%	2.4	2.3	2.3	-83%	-84%	-84%
Fossil fuels	2.0	1.5	-0.6%	0.8	0.8	0.7	-49%	-46%	-55%
Raw material productivity (GDP/RMC in EUR per kg)	0.4	1.3		4.2	4.1	4.3			
Ecosystem services									
Water exploitation index (WEI)	3%	5%		4%	5%	3%			
Total domestic harvest of crops in bln EUR	9	20	2.0%	18	20	14	-12.3%	-2.5%	-30.0%
Average domestic crop production price	1.00	1.07	0.1%	1.05	1.05	1.09	-1.5%	-1.3%	2.2%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

Sweden	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	342	611	1.5%	610	611	529	-0.2%	0.0%	-13.4%
Disposable income of households	246	454	1.5%	456	456	401	0.4%	0.5%	-11.8%
Household consumption	136	253	1.6%	258	258	187	2.0%	2.1%	-26.0%
Public consumption	91	183	1.8%	183	185	154	-0.3%	1.1%	-16.2%
Investments	60	127	1.9%	126	126	150	-0.2%	-0.2%	18.5%
Exports	162	297	1.5%	301	311	282	1.2%	4.6%	-5.0%
Imports	130	289	2.0%	300	314	283	3.8%	8.6%	-1.9%
Social indicators									
Employment in bln EUR	187	203	0.2%	203	203	162	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	56%	60%		59%	59%	60%			
Share of household expenditure for basic goods**	34%	19%		19%	19%	26%			
Environmental indicators									
CO2 emissions in Mt	52	38	-0.8%	21	22	20	-44%	-42%	-47%
Raw material consumption (RMC) in tonnes per capita	24.6	19.9	-0.5%	10.7	11.0	9.9	-46%	-45%	-50%
Biomass	3.4	2.6	-0.7%	1.9	2.1	1.6	-26%	-19%	-40%
Wood	2.2	1.6	-0.8%	1.3	1.3	1.1	-20%	-21%	-32%
Metal ores	3.5	2.9	-0.5%	1.7	1.8	1.7	-40%	-39%	-40%
Non-metallic minerals	11.9	10.9	-0.2%	4.6	4.6	4.5	-58%	-58%	-59%
Fossil fuels	3.6	1.9	-1.6%	1.1	1.3	1.0	-40%	-31%	-45%
Raw material productivity (GDP/RMC in EUR per kg)	1.5	2.8		5.2	5.1	4.9			
Ecosystem services									
Water exploitation index (WEI)	1%	2%		2%	2%	2%			
Total domestic harvest of crops in bln EUR	2	3	1.0%	3	3	3	-15.8%	-6.0%	-17.2%
Average domestic crop production price	1.02	1.15	0.3%	1.16	1.16	1.21	1.2%	0.7%	5.1%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

Slovenia	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	37	107	2.7%	106	106	93	-0.8%	-0.6%	-12.7%
Disposable income of households	26	68	2.4%	68	67	60	-0.1%	-0.7%	-12.1%
Household consumption	16	52	2.9%	53	52	38	1.5%	1.0%	-26.7%
Public consumption	6	17	2.5%	17	17	15	-1.6%	0.3%	-16.1%
Investments	10	26	2.5%	25	25	30	-4.0%	-5.3%	17.4%
Exports	23	58	2.3%	57	60	54	-1.7%	2.8%	-6.9%
Imports	22	52	2.2%	51	53	49	-2.2%	2.4%	-6.9%
Social indicators									
Employment in bln EUR	18	13	-0.7%	13	13	11	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	51%	47%		47%	46%	47%			
Share of household expenditure for basic goods**	32%	7%		7%	7%	10%			
Environmental indicators									
CO2 emissions in Mt	17	17	0.0%	8	8	7	-53%	-53%	-57%
Raw material consumption (RMC) in tonnes per capita	24.5	30.5	0.5%	16.7	16.7	16.4	-45%	-45%	-46%
Biomass	3.0	2.9	-0.1%	2.1	2.2	1.6	-27%	-22%	-43%
Wood	0.7	1.0	0.7%	0.8	0.8	0.6	-21%	-23%	-33%
Metal ores	1.2	1.9	1.2%	1.0	1.1	1.0	-45%	-44%	-45%
Non-metallic minerals	16.2	22.2	0.8%	11.5	11.2	11.9	-48%	-50%	-46%
Fossil fuels	3.4	2.5	-0.8%	1.3	1.5	1.2	-48%	-42%	-53%
Raw material productivity (GDP/RMC in EUR per kg)	0.7	1.8		3.2	3.2	2.8			
Ecosystem services									
Water exploitation index (WEI)	3%	5%		4%	4%	4%			
Total domestic harvest of crops in bln EUR	1	2	2.5%	2	2	1	-14.0%	-1.1%	-21.4%
Average domestic crop production price	1.01	0.80	-0.6%	0.80	0.80	0.79	-0.3%	0.2%	-1.7%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

Slovakia	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	68	236	3.2%	235	236	215	-0.6%	-0.2%	-9.1%
Disposable income of households	47	139	2.7%	139	139	126	0.0%	0.3%	-9.2%
Household consumption	33	133	3.5%	136	136	104	2.5%	2.6%	-21.4%
Public consumption	12	34	2.7%	32	33	28	-5.0%	-1.7%	-15.7%
Investments	17	47	2.6%	46	45	63	-3.3%	-4.1%	33.2%
Exports	51	148	2.7%	142	148	136	-4.2%	-0.2%	-8.0%
Imports	49	133	2.5%	128	134	123	-4.3%	0.5%	-7.8%
Social indicators									
Employment in bln EUR	23	17	-0.7%	17	17	14	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	36%	31%		31%	31%	31%			
Share of household expenditure for basic goods**	31%	5%		5%	5%	7%			
Environmental indicators									
CO2 emissions in Mt	36	54	1.0%	28	29	27	-49%	-47%	-50%
Raw material consumption (RMC) in tonnes per capita	15.1	23.1	1.1%	12.3	12.5	12.4	-47%	-46%	-46%
Biomass	2.5	2.9	0.4%	2.1	2.3	1.7	-27%	-21%	-41%
Wood	0.7	1.2	1.3%	0.9	0.9	0.8	-20%	-23%	-30%
Metal ores	0.9	1.8	1.6%	1.0	1.0	1.0	-47%	-46%	-47%
Non-metallic minerals	8.5	14.9	1.4%	6.9	6.8	7.6	-54%	-54%	-49%
Fossil fuels	2.5	2.4	-0.1%	1.4	1.5	1.3	-41%	-35%	-45%
Raw material productivity (GDP/RMC in EUR per kg)	0.8	2.0		3.6	3.6	3.3			
Ecosystem services									
Water exploitation index (WEI)	1%	2%		2%	2%	2%			
Total domestic harvest of crops in bln EUR	2	6	2.4%	5	5	4	-13.2%	-1.5%	-22.7%
Average domestic crop production price	1.01	1.09	0.2%	1.13	1.11	1.17	3.6%	1.4%	7.1%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

** the level of expenditure for basic goods is estimated using the LES-CES demand function that identifies a necessity level of consumption per product group

United Kingdom	Reference scenario			Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
	2010	2050	2010-2050 annual % change	2050	2050	2050	2050 % difference compared to reference scenario in the year 2050		
Economic indicators in bln EUR*									
GDP	2,012	3,714	1.5%	3,696	3,704	3,235	-0.5%	-0.3%	-12.9%
Disposable income of households	1,763	3,053	1.4%	3,063	3,014	2,670	0.3%	-1.3%	-12.6%
Household consumption	1,124	2,051	1.5%	2,082	2,067	1,498	1.5%	0.8%	-27.0%
Public consumption	472	931	1.7%	917	919	781	-1.6%	-1.4%	-16.1%
Investments	337	616	1.5%	613	611	891	-0.5%	-0.9%	44.5%
Exports	509	1,009	1.7%	987	1,029	892	-2.2%	2.0%	-11.6%
Imports	551	1,080	1.7%	1,076	1,105	989	-0.4%	2.3%	-8.4%
Social indicators									
Employment in bln EUR	1,128	1,273	0.3%	1,273	1,273	1,018	0%	0%	-20%
Unemployment indicator			0%				0%	0%	0%
Labour income in share of total primary income	56%	55%		55%	54%	55%			
Share of household expenditure for basic goods**	35%	21%		20%	21%	28%			
Environmental indicators									
CO2 emissions in Mt	513	286	-1.5%	141	143	128	-50%	-50%	-55%
Raw material consumption (RMC) in tonnes per capita	19.0	14.4	-0.7%	7.0	7.3	6.5	-51%	-50%	-55%
Biomass	3.9	2.8	-0.9%	2.1	2.2	1.6	-26%	-21%	-41%
Wood	0.8	0.6	-0.5%	0.5	0.5	0.4	-20%	-24%	-35%
Metal ores	1.5	1.5	-0.1%	0.8	0.8	0.8	-47%	-47%	-47%
Non-metallic minerals	8.3	7.6	-0.2%	2.6	2.6	2.7	-65%	-66%	-65%
Fossil fuels	4.4	2.0	-2.0%	1.1	1.2	1.0	-45%	-39%	-51%
Raw material productivity (GDP/RMC in EUR per kg)	1.7	3.5		7.2	7.0	6.9			
Ecosystem services									
Water exploitation index (WEI)	13%	18%		16%	17%	13%			
Total domestic harvest of crops in bln EUR	14	20	0.9%	17	20	16	-14.8%	-1.3%	-20.8%
Average domestic crop production price	1.02	1.18	0.4%	1.18	1.18	1.22	0.7%	0.1%	4.0%

Source: EXIOMOD 2.0
* all monetary values are expressed in 2007 prices

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