Macroeconomic modelling of sustainable development and the links between the economy and the environment

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Executive Summary

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Disclaimer: this report represents the views of the consultants, and not necessarily of the European Commission.
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The purpose of the MACMOD project by Cambridge Econometrics, GWS, SERI and the Wuppertal Institute was to strengthen the economic underpinning for resource policy. Besides the methodological progress that was achieved within the architecture of the both energy-economy-environment models involved (E3ME, GINFORS) the study gives some new insights to the following questions:

- Why is it reasonable to care about the resource use in Europe? → Risks of Resource use in Europe
- Why should we not trust in the market forces alone? → Market failures
- How did resource use on national level evolve in the recent past and what are likely developments in the future, if we pick up all the resources embedded in traded goods as well as the unused extractions? → National total material requirement (TMR) data and baseline results
- Would a reduction of resource use through (marginal) changes of production processes lead to abatement costs? → Abatement cost curves for material requirement
- What are the likely impacts of a set of simplified displayed resource policy options on economy and environment? → Policy simulations

**The Modelling Framework**

The analysis uses two models - E3ME and GINFORS. These are European (E3ME) or global (GINFORS) multisector/multicountry economic models, which calculate in a comprehensive way the pressure from economic activities on the environment. Both models are based on the same philosophy that agents make decisions in imperfect markets under conditions of bounded rationality. The parameters of both models are estimated econometrically, which gives them an empirical evaluation.

Nevertheless there are a number of different characteristics, which lead to different results: the data base is different, the regional and sectoral structures are different, and the specifications of the equations are not identical. This creates a variety of results, which is useful as it shows the effect of specific modelling assumptions and acts as an indicator for the robustness of the results.

This research strategy was already successfully applied in the PETRE project (Ekins and Speck 2011), which analysed the potential of an Environmental Tax Reform in Europe for both energy and the total of direct material inputs (DMI). In the MACMOD project the material modelling approach is more comprehensive as it uses the indicator Total Material Requirement (TMR), which includes hidden material flows of imported goods that are indirectly induced abroad as well as so-called “unused materials” in compliance with the following classification:

- **metals**
  - iron/steel
  - non-ferrous metals
  - other

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1 MACMOD: Macroeconomic modelling of sustainable development and the links between the economy and the environment. Study financed by the European Commission, DG ENV.
This extension is useful, because it allows observation of the substitution of direct material inputs by imported goods. Since the EUROSTAT data contains only direct material input it was necessary to calculate in the project TMR data for all European countries.²

Risks of Resource use in Europe

The study starts with an analysis of the different risks associated with future resource use in Europe. The key output is a matrix of risks for important resource categories, with information on the nature of the risks, timescales, examples and quantifications of risks as well as their economic, environmental and social impacts.

The risk analysis covers the following eight resource categories: Metals – Iron and Steel, Metals – Other Metals, Minerals – Construction Minerals, Minerals – Industrial Minerals, Fossil Fuels, Biomass – Agriculture, Biomass – Fish, Biomass – Wood. These resource categories give one dimension of the risk matrix. In contrast to most other studies on resource use risks, we describe risks for these broad resource categories rather than at higher levels of disaggregation, e.g. at the level of single metals or minerals. We provide examples for specific resources but stay at the broader category in order to give a broad overview of potential future risks related to resource use. This approach was also selected in order to provide information at a level of aggregation which the modelling partners could integrate in their scenario simulation models.

Building on existing studies we developed a framework of risks, clustered in the following four major risk categories:

- **Availability**: geological and ecological availability
- **Technology-related risks**: extraction technologies, substitution and recycling options
- **Economic and policy related risks**: economic availability, power concentration, import dependency, development of resource prices, economic vulnerability
- **Environment-related risks**: environmental impacts, risk of environmental catastrophes

The analysis reveals that, with regard to the categories of metals and minerals, the main risks are found in similar categories. In particular, the high market concentration is

² The input indicators DMI and TMR - in contrast to the indicators Direct Material Consumption (DMC) and Total Material Consumption (TMC) - account not only for those resources that are needed to meet the domestic demands but for the whole material inputs that are used across an economy, independent from the question whether they are used for the production of goods for domestic or international markets.
associated with high risks of supply restrictions and power of a few global players on the world market prices. In addition, import dependency is high for a number of materials in those categories. The second main risk regarding those materials is limited options to substitute or recycle, although potentials are high to increase the share of secondary materials.

Regarding fossil fuels, the main risks arise in the areas of geological availability (“peak oil”) and high import dependencies of Europe particularly regarding oil and gas. Climate change poses a heavy environmental risk associated to this material category.

The three material categories of biotic resources, agriculture, wood and fish share equal risks with regard to threats of limited ecological availability, such as limited availability of water and fertile land for agricultural production and limited fish stocks as well as environmental impacts, such as biodiversity loss and climate change impacts.

<table>
<thead>
<tr>
<th>Availability</th>
<th>Iron &amp; steel</th>
<th>Other metals</th>
<th>Construction minerals</th>
<th>Industrial minerals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geological availability</td>
<td>Iron production is energy intensive, but usable deposits of iron ore are geographically widespread</td>
<td>Rare earths: widespread resources in all continents</td>
<td>In some EU countries limited geological availability and topographical accessibility</td>
<td>Most industrial minerals are abundantly available in the earth crust, so generally low risk</td>
</tr>
<tr>
<td>Ecological availability</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extraction technologies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td>Substitution and recycling options</td>
<td>Increasing options to substitute iron and steel; increasing shares of scrap iron</td>
<td>Rare earths: limited recycling options</td>
<td>Potentials to recycle are high; shares in practice very different</td>
</tr>
<tr>
<td>Economic and policy issues</td>
<td>Economic availability</td>
<td>Restrictions due to competition for land</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power concentration</td>
<td>3 biggest iron ore producers control 75-80% of global supplies</td>
<td>High market concentration for some critical metals (e.g. antimony, gallium, germanium, indium, rare earths, tungsten largely from China)</td>
<td>High supply concentration for certain minerals (e.g. graphite); Barriers to trade</td>
<td></td>
</tr>
<tr>
<td>Import dependency</td>
<td>High but not critical EU dependency on imported iron ore</td>
<td>Europe is 100% import dependent for many rare metals (e.g. rare earths)</td>
<td>High import dependency related to some IndM (e.g. phosphorous)</td>
<td></td>
</tr>
<tr>
<td>Resource prices</td>
<td>Still among the cheapest metals, but expected future price increases may have economic impacts</td>
<td>Metals industry depends on several energy sources, most importantly electricity</td>
<td>Increase in the long run if spatial planning policies are not implemented</td>
<td>Global demand trends lead to price rise for certain IndM</td>
</tr>
<tr>
<td>Economic vulnerability</td>
<td>Very high economic importance, as almost all industrial sectors depend on iron; EU is second largest manufacturer of iron and steel in the world</td>
<td>High importance of rare metals for many low-carbon technologies; Dependency of modern technology on aluminium, lead, copper</td>
<td>Sensitive to transport costs, have to be sourced locally</td>
<td>High importance in a wide range of industries; many IndM cannot be substituted</td>
</tr>
</tbody>
</table>
Environmental impacts

Globally, primary iron & steel production have the largest negative env. impacts of all metals (sector with very high energy intensity)

Mining of critical metals often causes considerable environmental burden, but their use in low-carbon may also bring environmental benefits

Landscape and habitat disruption. Emissions related to extraction, transport, processing and deposit

Related to extraction, transport, processing and deposit

Risks of natural catastrophes

Japan is the largest global supplier of iron and steel; 5 Japanese mills are located in Tsunami affected areas

Geological availability

Resources will be diminishing in the medium-term

Critical availability of phosphorous

Overfishing leads to collapsing fish stocks in the EU (and globally)

Ecological availability

Critical availability of land and water

European forests are generally well managed; continuous deforestation outside the EU due to land use change

Technology

Extraction technologies

Become more complex and more expensive

Limited substitution in aquaculture production of fish

Substitution and recycling options

High dependence on FF in energy supply. After combustion not available for recycling

Economic and policy issues

Economic availability

Supply is highly concentrated

Future economically viable phosphorus reserves are concentrated in China and Morocco

Resource prices

Long-term price rise; price volatility and shocks

Rising food prices

Higher future prices due to increasing use of timber for energy and construction and growing global demand

Economic vulnerability

Dependence on ff in energy supply, transport and industrial processing; increasing demand

Negative impacts on fishery industries; fleets become increasingly economically unviable; employment is endangered

Environmental impacts

Fossil based emissions induce global warming

Climate impacts; soil degradation; water scarcity; biodiversity loss, etc.

Loss of forests due to conversion in agricultural land; climate change impacts

Biodiversity loss, destruction of vulnerable habitats, decreasing stability and water quality

Risks of natural catastrophes

Reduced yields/harvests due to environmental impacts (climate change!!)

Increasing intensity and frequency of extreme weather events due to climate change

**Table 2:** Matrix of risks associated with future European resource use
Market Failures

A strong conclusion of the project is that policies matter. Despite the argument that increasing commodity prices will deliver resource savings, both theoretical and empirical evidence suggests that this incentive alone is unlikely to be translated into continuous and far-reaching resource efficiency performance improvements. It is even less likely to stimulate product innovation and system innovation that help to reduce the use of primary materials in the EU.

Overall, the enormous importance of externalities, information deficits, adaptation and coordination deficits are highlighted, both from a theoretical and an empirical perspective:

- Positive externalities associated with eco-innovation that pose barriers to entrepreneurs and product innovation,
- Wide-spread information deficits as regards to potentials for saving material purchasing costs within companies and across industries,
- More fundamental information deficits concerning uncertainties about future demand for new eco-innovations, including in critical areas such as construction,
- Adaptation and coordination deficits with regard to existing market power, path dependencies and difficulties to finance mass market development of radical innovations.

Baseline Results for Material Requirements

Baseline assumptions about raw material prices and energy policy have been taken from the PRIMES reference scenario, which assumes that the EU ETS, energy efficiency programs outside the ETS and measures for a rise of renewable energies are the main instruments of energy policy in Europe till 2030. Both models calculated on this basis a further rise of TMR for most European countries till 2030 and on average a rise of TMR of between 2.5% and 11% (E3ME and GINFORS). Since growth in GDP is faster, both model baselines forecast a relative, but not an absolute decoupling of economic development from material requirements.

<table>
<thead>
<tr>
<th>Total Material Requirement</th>
<th>2010</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>domestic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>used</td>
<td>19.7%</td>
<td>14.9%</td>
</tr>
<tr>
<td>unused</td>
<td>23.7%</td>
<td>19.0%</td>
</tr>
<tr>
<td>imports</td>
<td></td>
<td></td>
</tr>
<tr>
<td>used</td>
<td>11.1%</td>
<td>11.7%</td>
</tr>
<tr>
<td>hidden flows</td>
<td>45.5%</td>
<td>54.4%</td>
</tr>
<tr>
<td>Material categories</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td>23.2%</td>
<td>26.7%</td>
</tr>
<tr>
<td>Metals</td>
<td>24.9%</td>
<td>30.8%</td>
</tr>
<tr>
<td>Non-metallic minerals</td>
<td>18.9%</td>
<td>15.9%</td>
</tr>
<tr>
<td>Fossil energy materials/carriers</td>
<td>28.3%</td>
<td>22.0%</td>
</tr>
<tr>
<td>Others</td>
<td>4.7%</td>
<td>4.7%</td>
</tr>
</tbody>
</table>

Table 2: Changes in the composition of average national TMR of EU27 Member States in the baseline projection of GINFORS up to 2030, GINFORS

Table 1 shows (under baseline assumptions) an ongoing shift to the foreign parts of TMR. By 2030 the import share will reach on average over all Member States 66.1%. If
we take a look at the different material categories within TMR we observe not only a rising relevance especially of metal ores but also of biomass. Our analysis and that of the International Resource Panel (UNEP 2010) suggests that these categories are the most environmentally-intensive and require an active abatement policy that stretches out to the exporting regions outside the EU.

**Top down abatement cost curves for material inputs**

Cost curves for the abatement of CO2-emissions play an important role in the discussion of alternative approaches in energy policy. These cost curves are based on bottom-up information, i.e. on detailed technical descriptions of different technologies that allow direct calculations of their respective installation costs. A very popular example are the cost curves produced by the consultancy McKinsey: originally for climate emissions and more recently McKinsey also presented first abatement costs curve estimates with regards to resources (McKinsey Global Institute 2011).

The McKinsey analysis is essentially bottom-up in nature, whilst the analysis in our modelling is essentially top-down in nature. However, both approaches tell the same analytical story and their results are consistent and supporting; and are also supported by additional analysis and ad-hoc studies [provide the example from the German information campaign here].

Our approach has been developed based on the fact that material inputs are to a very large extent determined by only 30 input coefficients. The EU input output tables distinguish 60 sectors, which gives $60 \times 60 = 3600$ monetary input flows across the economy. A reduction of each of them by 1% will induce directly and indirectly a certain amount of reduction of material inputs in physical terms. But if we look at the result for the 30 most important monetary inputs in that context, we see that they achieve already 50% of the reduction of physical material input that we get, if all 3600 inputs would have been reduced by 1% (Distelkamp et al. 2005).

We ran 30 individual model simulations, each assuming a simultaneous 1% reduction in only one of these 30 most important input coefficients in the European Member States’ input output relationships. As the applied models are able to calculate the induced cost, price and income reactions, each simulation thus pictures (i.a.) the overall change in GDP and total material requirements in a cohesive framework. According to our view, these changes in GDP and total material requirements can be interpreted as individual data points of a marginal abatement cost curve. Hence, our curves have been obtained by sorting these data points with regards to their implied macroeconomic costs (defined as percentage reductions in real GDP (see Cambridge 2011 or Distelkamp et al. 2011 and the references therein for further details).

Figure 1 shows the aggregated short run effects after 1 year. Costs are measured as percentage deviations of real GDP in the average over Member States, reductions of material inputs are measured as percentage deviations of national total material requirements in the average over Member States.

A comparison of the short run curves shows that both models estimate for a broad range of input coefficients negative costs, which means a surplus in terms of GDP. In other words: a win-win result with rising GDP and reductions of TMR. In the case of E3ME this is given for (nearly) all of the 30 coefficients. The cumulative reductions of TMR are in the
case of GINFORS much greater than for E3ME. The reason is that GINFORS has much more complementarities between the material relevant coefficients and the other coefficients than E3ME. In GINFORS for example the reduction of metal inputs in the industry “motor vehicles” reduces the input of electricity in this sector. This means that there are two channels through which demand reduction and the further reduction of material inputs takes place: The production of “basic metals” and “electricity” are reduced simultaneously. Without this complementary relation in the sector “motor vehicles” the channel would be only via production of “basic metals”. So the reduction of the coefficient in the simulation induces further reductions of others in GINFORS, but not in E3ME.

![Graph showing short run abatement cost curves](image)

**Figure 1:** Short run abatement cost curves

### The Policy Scenarios

Three hypothetical policy scenarios were examined, to show the potential impact of resource efficiency policies. The focus of attention should though be on the potential for win-wins, rather than the specific policies to deliver those benefits, which were not the focus of this study.³

³ For example, in the context of metals, the substitutability between metals and other competing materials and the possible impacts in terms of distortion of competition are not fully taken into account. In a fuller assessment, the possible impact on the concerned sectors and their competitive position both on domestic and international market would also need to be examined further. In the EU, recycling rates for metals are high in comparison to other materials and the supply of scrap of required quality is limited. From this perspective, taxation applied to metal input might have only very limited effects on the recycling rate of metals. Finally, the distributional effects that a tax applied to a specific group of industries is likely to have would need to be studied in detail.
Since the inputs of fossil fuels are not in the scope of the project, the interesting drivers of material inputs are mainly manufacturing and construction sectors:

- Construction is using in the first line non metallic minerals, manufacturing sectors are responsible for all kinds of materials.
- Metals which - as a strategic input to many production processes - seem to offer particularly large opportunities (UNEP and CSIRO (2011)) are concentrated in manufacturing.  

Metals are produced in the basic metals industries and the most important users of metals are the investment goods industries. “Basic metals” aggregates the industries “iron and steel” and the industry “non-ferrous metals”. Taxing the input of ores without a border adjustment raises domestic prices and induces the substitution of domestically produced metals by imports. This expected result is confirmed by simulations with GINFORS and the impact on metal requirement in physical terms is low.

The alternative and the policy examined is to push the substitution of metal ores by recycled material through a negotiated agreement. Given growing worldwide awareness of emerging scarcities it seems plausible that metal producer countries facing an oligopoly of ores producers will be seeking for international negotiated sector agreements strengthening their market power. The agreement itself could also be understood as an announcement by

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4 Metals represent a resource where future supply might not be able to meet worldwide demand which will be boosted by rapid economic growth in Asia (Halada et al. (2009)). McKinsey forecasts a rise of global steel demand of 80% till 2030 (McKinsey Global Institute 2011). A further problem is given by the high concentration on the supply side: In the case of iron ore only three firms control 80% of global supply (Pirgmaier et al. 2011). On the other side, metal extraction causes environmental damages of the worst kind during its transport and processing and the use of stocks made of it – like cars - induces high energy consumption.

5 De Clerq (2002) mentions three positive factors for the success of such an instrument, which are all given for the “basic metals” industry: A homogenous product, a small number of players, and an industry that is dominated by some or has a powerful association.

6 The chances for a global agreement are good, because two very important producers of basic metals have already installed general plans for the improvement of recycling: China introduced in 2008 the “Circular
basic metal producing countries, threatening the taxation of ores inputs in the production of basic metals unless the input coefficient in constant prices for ores do not exceed the corresponding ones of secondary materials from 2030 onwards: The European basic metals industries reduce their inputs of ores and raise the inputs of secondary materials until the expenditures in constant prices for secondary materials at least equal those for primary materials. Further the material intensities of imported products fall by 50% because basic metals produced abroad and the metal products produced with them have also less content of ores.

**Investment Goods Industries**

Industries producing investment goods and consumer durables are the most important users of metals. The policy examined is a tax on the nominal input of metals with a rate rising from 1% in 2011 to 70% in 2030. The use of metals in these sectors is less determined by technological constraints. Here product design and the product mix are of much more importance for deciding the input of metals. To provide an example we refer to Bringezu and Bleischwitz (2009): Even in absence of any technological changes cars might be produced with less metal inputs. Furthermore, even if we assume a given product design, a change of the mix of existing car types influences metal consumption. Thus, we assume an increasing flexibility in the use of metal inputs for later stages of the metal supply chain.

**Other Manufacturing Industries**

The policy examined in this case is information programmes. With the exception of the chemical industry all other relevant manufacturing sectors are more or less small or medium sized firms (SME). Many studies have shown (Bleischwitz and Ritsche 2011) that especially SME’s suffer from market failures concerning material inputs, which in many cases are based on information deficits about the technical alternatives and different product designs. Empirical evidence from consulting firms approves this indication: ADL found out that 20% of material inputs can be saved permanently at the cost of the savings for one year (Fischer et al. 2004, ADL et al. 2005). Oakdene Hollins (2011) provide comparable findings.

We assume that all SMEs in the manufacturing sectors might overcome these market failures within a 20 years horizon. With regards to the gains and the costs of this operation we follow Fischer et al. (2004): It is assumed that the consulted firms are able to reduce their expenditures for deliveries of intermediate products of materials permanently by 20%. On the other side they have additional costs for consulting only in the first year, which equals the savings of material inputs for one year. The reactions of physical material inputs are endogenous.

**Construction**
Recycling of construction minerals means that in the construction sector the inputs delivered by the mining and quarrying sector will be reduced and substituted recycled materials.

**Simulation Results**

Table 3 sets out the results for GDP and employment with further macroeconomic information on real household spending and consumer prices. We see that in nearly all the scenarios and for both models positive effects on GDP and employment are accompanied by positive effects on real household spending and (with one exception) with falling consumer prices. The exception concerns the GINFORS results for the taxation scenario, where different price elasticities of metal inputs in the investment goods industries are responsible for the result of slightly rising prices for investment goods, which diffuses through the economy and raises very slightly also consumer prices.

In the **information scenario** prices fall stronger in the GINFORS simulation than in the E3ME simulation and GDP rises stronger in the GINFORS simulation. The reason for this is that in the E3ME simulation fewer industries are covered under this scenario. Since the additional costs for consulting services equal the material savings of one year, the sectors under the program realize a reduction of unit costs and prices, which raises domestic and international demand. On the other side value added in those sectors that deliver the saved materials will fall. The strength of this effect depends on the relation between imported and domestically produced materials that are saved.

Table 4 summarizes the results for TMR. The **taxation scenario** has some smaller side effects on biomass and non-metallic minerals. The point of interest is of course the effect on metals. For E3ME the impact is at -3.1% much lower than for GINFORS (-10.9%). The explanation is given with a rebound effect which is calculated by E3ME as a consequence of falling prices in the investment goods industries. GINFORS has lower price elasticities for the inputs of metals, which pushes a slight rise of prices in the investment goods industries and thus avoids the rebound effect.

<table>
<thead>
<tr>
<th>summary economic impacts</th>
<th>Taxation</th>
<th>Recycling</th>
<th>Information</th>
<th>Policy mix</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E3ME</td>
<td>GINFORS</td>
<td>E3ME</td>
<td>GINFORS</td>
</tr>
<tr>
<td>GDP</td>
<td>1.5%</td>
<td>0.2%</td>
<td>-0.2%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Employment</td>
<td>0.2%</td>
<td>0.0%</td>
<td>0.6%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Household spending</td>
<td>1.1%</td>
<td>0.4%</td>
<td>0.3%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Consumer prices</td>
<td>-0.4%</td>
<td>0.1%</td>
<td>-0.2%</td>
<td>-0.1%</td>
</tr>
</tbody>
</table>

Source(s): E3ME, Cambridge Econometrics; GINFORS, GWS

Table 4: Summary economic impacts. Deviations from the baseline in per cent.

In the **recycling scenario** both models give similar and expected results for the use of metals. For non-metallic minerals the differences between the models result from differences in scenario assumptions: The E3ME team analysed recycling generally of construction minerals, whereas the GINFORS team considered only the impact of a reduction of the inputs of non-metallic minerals delivered from the mining and quarrying sector to the construction sector.

The E3ME results for the **information scenario** show strong reductions for biomass. The rise of construction minerals, which dominates the result for non-metallic minerals, is
more surprising but is explained by the choice of sectors targeted; construction was not part of the programme but non-metallic mineral products was included, leading to lower prices for construction minerals and an increase in demand. That use of metal ores reduces less than the use of biomass is plausible since the sectors under the program are not metal intensive. GINFORS calculates smaller reductions for biomass, since agriculture is not included in the information program in the GINFORS simulation. Generally the reductions are lower than for E3ME (exception: construction minerals). The reason is that sectoral and economy wide rebound effects play a bigger role, because price reductions are stronger for GINFORS than for E3ME.

Taking the differences in scenario formulations into account we observe for both models similar reactions. Of course the similarities are greater where the driving forces are more exogenous – as in the recycling scenario – and they are smaller the more endogenous the adjustment mechanisms are – as in the information scenario.

The impact on CO2 emissions are not a focus of this project, but of course have been calculated. For the policy mix scenario E3ME measures a reduction of -0.4%, which gives with rising GDP an increase of energy efficiency of 2.2%. In the case of GINFORS The input of fossil energy carriers, which are not subject of the policy instruments, are reduced by -3.9% in spite of the positive GDP effect. This means that our policy mix for a higher material efficiency indirectly raises efficiency for fossil energy carriers by +7.2%. In other words, there are strong co-benefits in the sense that resources policy will also deliver climate change benefits.

<table>
<thead>
<tr>
<th>Weigted averages of material impacts (TMR) among the countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass material requirement</td>
</tr>
<tr>
<td>E3ME</td>
</tr>
<tr>
<td>0.1%</td>
</tr>
<tr>
<td>Non-metallic minerals material requirement</td>
</tr>
<tr>
<td>Metal ores material requirement</td>
</tr>
<tr>
<td>Others (MF 5)</td>
</tr>
<tr>
<td>Total material requirement</td>
</tr>
</tbody>
</table>

Source(s): E3ME, Cambridge Econometrics; GINFORS, GWS

Table 4: Impact on material use. Weighted averages of the country specific results. Deviations from the baseline in the year 2030 in per cent.

Figure 2 presents some further insights into the GINFORS results of the policy mix scenario. Shown are indices for GDP in constant prices and for metals material requirement, both set to 100 in 2010 (the starting point of the simulation corresponds to the year 2011). In 2030 GDP is 51 % higher and the material requirement of metals including the hidden flows is 26% lower than in 2010. That is absolute decoupling! Also for TMR absolute decoupling is given: Total Material Requirement in 2030 is 8.1% lower than in 2010.
Results of the policy mix scenario with GINFORS

Conclusions

The main conclusion from the project is that EU Member States face the risk of importing more and more materials. In this regard metals, biomass and industrial minerals seem to constitute a major problem as they contribute the largest share to Total Material Requirements of Member States of the EU. Europe is therefore outsourcing environmental pressures. A development which tends to intensify economic and geopolitical risks is supply restrictions and dependency on few companies and countries for access to natural resources. Only a policy that actively addresses those inputs and the material consumption that goes along with it can ensure absolute decoupling of GDP growth from total material requirements.

Given our overall findings we therefore see strong arguments in favour of a policy mix to stimulate an increase in resource productivity. For GDP and employment positive effects are likely. Summarizing the results of the simulation experiments with both models the following rule of thumb can be derived as an average for the Member States of the EU: A reduction of TMR by 1% is accompanied by rise of GDP between 12 and 23 billion € and a rise of employment between 0.04% and 0.08%, which for EU27 means a number between 100,000 and 200,000 people. With the calibration of the policy measures that we have chosen in our experiments, TMR in Member States would be reduced by on average between 17 and 24 %. GDP in constant prices would rise in the European Union totally between 240 and 380 billion € and employment would improve by 1.4 to 2.8 million people.