



Pathways to a Resource-Efficient and Low-Carbon Europe – Lessons from the Modelling

SUMMARY OF KEY POINTS

- Maintaining a Business-as-Usual approach to policy, industrial activities and behaviour in civil society has increasingly negative environmental, economic and social consequences.
- Global cooperation on policy measures to keep global warming below 2°C and to boost resource efficiency would not only allow maintenance of planetary boundaries, but would also be beneficial for green growth and jobs in the EU.
- If a global consensus not only on targets but also on binding policies cannot be achieved in the near future, Europe should go ahead. The modelling results show that this is, from an economic perspective, even more successful if the policy measures are designed in the right way.
- Modelling results for the contributions of civil society to a reduction in resource use show the immense potentials of changing values and behaviours in society.

The POLFREE (POLicy options For a Resource-Efficient Economy) project explored drivers and barriers for a resource-efficient economy in Europe. The project investigated why resources have been used inefficiently, developed new concepts and paradigms for resources efficiency, and examined through modeling different policy scenarios for resource efficiency. This Policy Brief belongs to a series of five, listed below. These, and all other project outputs, may be found at www.polfree.eu

POLICY BRIEF SERIES

- 1 Understanding the Web of Constraints to Resource Efficiency in Europe – Lessons for Policy
- 2 Constraints to Resource-Efficient Consumer Behaviour
- 3 Constraints to Resource-Efficient Business Models and Practices
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The modelling of future scenarios for EU environmental policy has, until recently, only focused on individual aspects at a time (e.g. climate policy or abiotic raw materials). The simultaneous analysis of different environmental objectives, taking account of the complex interrelations between them, is new. What are the requirements for a policy mix, if the environmental targets of climate and resource policy are to be met simultaneously? What are the socio-economic impacts caused by these changes likely to be?

The POLFREE project sought to answer these questions, by undertaking an integrated assessment modelling exercise in which the economic-environmental models GINFORS (GWS) and EXIOMOD (TNO) were linked with the vegetation model LPJmL (PIK).

Both **economic models** (GINFORS, EXIOMOD) belong to the family of Environmentally Extended Global Multi Regional Input-Output (EE-GMRIO) models. Such models assess the interconnections between the environment and economy (energy use & emissions, resources) with a multi-region/multi-country perspective, and are characterised by global coverage and the ability to analyse impacts on economic sub-sectors and specific resource products. Two key differences may be found between the GINFORS and EXIOMOD models. First is the main source of historical data. GINFORS is based on the WIOD database, a global multiregional time-series of Input-Output tables with accompanying socio-economic and environmental data. EXIOMOD is based on EXIOBASE, which provides more sectoral detail but reports only for one historical year. Secondly, and most importantly, is the different theoretical and empirical foundation of the behavioral functions the models consider. GINFORS has a Neo-Keynesian theoretical background and all parameters of the model, like price elasticities and technical progress, are estimated econometrically based on historical observations. EXIOMOD in contrast is a Computable General Equilibrium Model (CGEM) with neoclassical theoretical foundations. The parameters of the model (elasticities, efficiency gains) are taken from literature or set by assumptions.

Three distinct resource-efficient, low-carbon scenarios, developed by the POLFREE project, were assessed. A set of about 30 different policy instruments (information, economic and regulation instruments) were allocated to each of the three alternative scenarios, with different governance and international cooperation assumptions. Each scenario was designed to meet, through different strategies, the following overarching targets for the EU:

- A reduction of CO₂ emissions by 80% compared with 1990,
- A reduction of the cropland footprint by 30% compared with 2005,
- A reduction of raw material consumption (RMC) to 5 tonnes per capita,
- A water exploitation index below 20% countries.

POLFREE SCENARIOS AT A GLANCE

- 1 Global Cooperation** – All countries co-operate through international agreements and harmonised economic and regulatory policy instruments to pursue decarbonisation and a resource-efficient global economy.
- 2 EU Goes Ahead** – The EU pursues the development of a low-carbon, resource-efficient economy unilaterally, through strong EU-level economic and regulatory policy instruments instituted by Member States. The rest of the world fails to increase existing ambition.
- 3 Civil Society Leads** – Civil society, NGOs and businesses drive resource-efficiency and decarbonisation through voluntary changes in preferences and behaviour. Policies are introduced to facilitate such changes.
- 4 Business-as-Usual** – An increasing focus or ambition surrounding decarbonisation of resource-efficiency in both EU and non-EU countries fails to materialise. This allows a comparative case against which conclusions surrounding the above scenarios may be drawn.

Conclusion 1

Different modelling approaches may produce very different projections

Whilst the scenarios applied to the GINFORS/LPJmL model coupling largely achieved the overarching targets described above, this was not the case with the EXIOMOD/LPJmL coupling. In the latter case, very strong rebound effects occur, with substantial conflict between the targets (see Hu et al. 2015, pp 24).

This discrepancy is caused by the different model parameterisations. All price and income elasticities in the demand and supply functions of GINFORS are estimated econometrically. The model has an empirically evaluated structure. In the case of EXIOMOD, the elasticities of substitution are assumed. This appears to have important ramifications. For example, the price elasticities for intermediate demand in EXIOMOD are assumed at zero, which means that taxation of resource intensive intermediate goods, as occurs in the resource-efficient scenarios applied to the models, is not able to change the structure of production directly. This is likely a key contributor to the inability of the EXIOMOD/LPJmL model coupling to successfully project a resource-efficient future.

Another factor is the projected effects of 'information' instruments. Information instruments induce improvements in resource productivity, which shifts supply functions to the right at all stages of production. For consumption goods, the price elasticity of demand is assumed as -1 – rather high in absolute terms. Here, the shift of the supply function to the right generates a new equilibrium with a lower price and a higher demand and production, which raises the input of resources. This rebound effect is strengthened by a strong reduction in imports, which have a price elasticity of -5. As such, the reduction of the consumer price will strongly reduce imports and increase domestic production further.

In GINFORS, intermediate demand is price dependent, with econometrically estimated differing elasticities for different product groups. Further, the econometrically estimated price elasticities of consumption and of imports are significantly lower than that of EXIOMOD, which reduces rebound effects. For these reasons, if the EXIOMOD/LPJmL model coupling were to reach the environmental targets outlined above, exogenously assumed, *ad hoc* improvements in the energy and material efficiency of the economy must be added. As

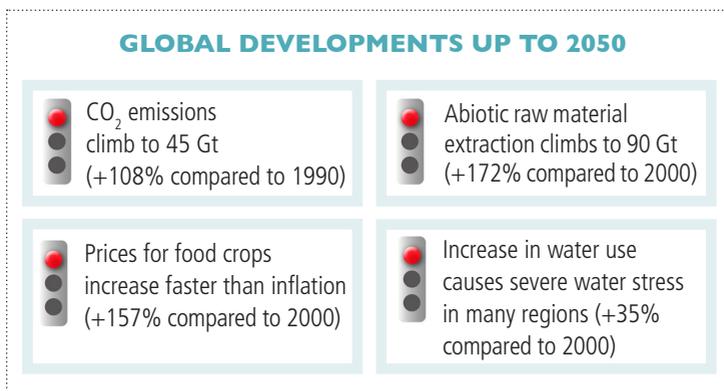
such, the results would only be in part induced by the policy mixes in each scenario, rather than by the dynamics of the model itself. Due to these factors and limitations, the remainder of the policy brief is focused on the results of the scenarios and policy mixes applied of the GINFORS/LPmL model coupling.

Conclusion 2

A Business-as-Usual scenario paints a gloomy picture for the global environment and prosperity

The Business-as-Usual scenario of the GINFORS/LPmL assumes that in the EU existing climate policy is maintained, and that no additional policy instruments reduce material extractions and improve resource efficiency are implemented. In non-EU countries, no environmental policy action at all is assumed. This simulates the effects of a world in which increasing focus and emphasis on environmental sustainability fails to materialise.

The results of the modeling exercise indicate that under the Business-as-Usual scenario, global CO₂ emissions will more than double to 2050 (against 1990 levels), driven by increasing consumption of fossil fuels. This indicates not only a pathway to substantial climate change, but also produces rapidly rising prices for fossil fuels, reflecting demand.



As a result of increasing pressure on available land and water resources, a dramatic increase in prices for food crops is also projected; particularly in developing countries. As such, the incidence of poverty may increase rather than diminish over time, along with the risk of significant famine events. Strong increases in raw material prices are also to be expected, as a consequence of rising demand and scarcities. Market forces alone cannot prevent continued increase of global abiotic raw material consumption (RMC) from 52 Gt in 2010 to 90 Gt in 2050. This hints not only at an accelerating unsustainable exploitation of natural resources, but also at the rising risk of resource conflicts.

In this context the EU would likely experience declining, but still slightly positive, GDP growth rates. However, a loss of more than 30 million jobs within the next 35 years hints at ongoing, and in some countries even rising, unemployment problems. Last but not least, public debt performance hints at the possibility of new financial crises arising (both within the EU and globally).

Conclusion 3

Global Cooperation would allow environmental targets to be achieved, whilst raising GDP and employment against Business-as-Usual

In the Global Cooperation scenario, all countries are not only committed to achieving the environmental targets presented above, they also act cooperatively in common purpose. The policy mix, which mainly consists of economic instruments and regulations implemented on the supply side of the economy, is applicable globally.

THE POLICY MIX (MAIN INSTRUMENTS)

Climate policy is focusing on the inputs of fossil fuels and has four pillars:

- An upstream carbon tax for all industries,
- A regulation of the share of renewables in electricity production,
- A set of regulations and economic instruments favouring e-mobility and
- Subsidies for investment in the energy efficiency of buildings.

Decoupling of economic development and the use of ores and non-metallic minerals is targeted by:

- The regulation for recycling of ores and non-metallic minerals,
- An upstream tax on ores and non-metallic minerals and
- A public innovation fund for the material efficiency.

Sustainable agricultural land and water use is targeted by:

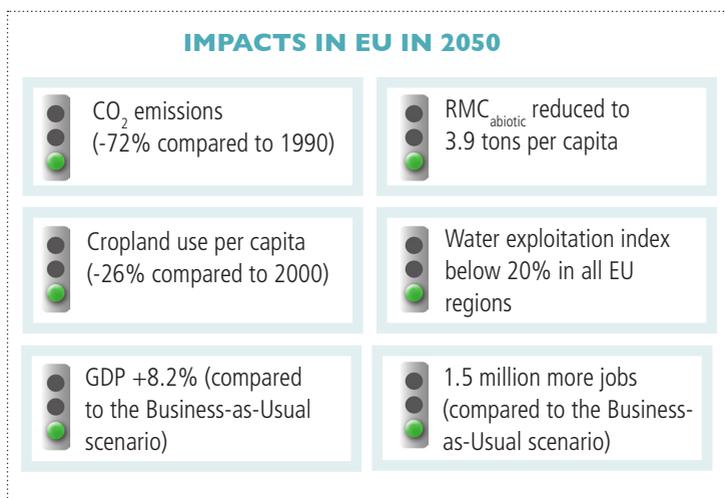
- A regulation for water abstraction of agriculture,
- An information program to avoid food waste,
- A tax on meat consumption and
- An information program to reduce the yield gap in agriculture.

Additional tax revenues are used for a reduction of taxes on goods and services with low carbon and resource contents.

In this scenario, global CO₂ emissions peak around 2020, and decrease thereafter to 11% below 1990 levels by 2050. Global raw material extractions also peak around 2020 and – despite a continued global increase in population – decrease by 13 Gt by 2050, against 2010 levels. All environmental targets for the EU are, for all practical purposes, met.

The policy mix induces strong investments in new resource-efficient technologies, reducing demand for resources, and consequently prices (including food prices), against the Business-as-Usual scenario. Social tensions arising from increasing food prices in the Business-as-Usual scenario are likely to be less prominent (if not diffused).

Global GDP is consistently higher than in the Business-as-Usual scenario (in 2050: +5.2%), whilst GDP in the EU is even stronger (in 2050: +8.2%), a function of the role of the EU as a consumer rather than producer of resources. Employment is also higher. Only for the industries 'mining and quarrying', 'coke and refined petroleum' and for 'food and beverages', value added is reduced against a Business-as-Usual trajectory. All other industries are 'winners', suggesting that instruments in the policy mix, when well targeted, may produce economic as well as environmental benefit, leading to 'decoupling' of economic growth and environmental degradation, both within the EU and globally.



Conclusion 4

If Global Cooperation cannot be achieved, substantial benefits remain if the EU pursues resource efficiency unilaterally

The EU Goes Ahead scenario assumes that, whilst the EU remains committed to the environmental targets outlined above, non-EU countries are not (with only moderate climate policy pursued).

In this scenario, whilst all environmental targets within the EU are met, due to only moderate climate policy in Non-EU countries, global CO₂ emissions remain on a trajectory a world of 4°C warming. Since the reduction of resource use by the EU has only a small effect on global resource demand, world market prices increase in line with the Business-as-Usual scenario. The EU is the only region in the world that rigorously improves its resource efficiency, and thus insulates itself to a degree from consequential increases in production costs.

The EU therefore realises a first-mover advantage. GDP in the EU is even stronger than in the Global Cooperation scenario, to 12.4% higher than the Business-as-Usual scenario by 2050, whilst employment is increased by 3.5 million jobs. As such, if global cooperation to achieve a resource-efficient, low-carbon economy is not forthcoming, unilateral action at the EU level to pursue these goals is clearly an economically attractive proposition.

THE POLICY MIX

The main change to the policy mix in the EU compared with Global Cooperation concerns the design of taxation instrument in a way that avoids problems with international competitiveness. The upstream carbon tax is substituted by an ETS system with a flexible supply for basic industries. For the other industries, a direct compensation of the tax (through revenue reallocation) has been assumed with gross production as the base for such reallocation. So the net charge for firms of the industry is proportionally linked to their CO₂ emissions. With full revenue reallocation, the average net cost to industry is therefore zero.

The upstream tax on non-metallic minerals is not a problem since the products made of these materials are barely in international competition. With metals the opposite is the case. Therefore the upstream tax on ores has to be substituted by a material tax on final demand with the exception of exports. This tax hits final products with high ore contents from domestic production and also the imports. Since exports are free there is no influence on international competitiveness. The revenues of the tax on non-metallic minerals and of the material tax on final demand are compensated by a subsidy on goods and services with low material content, so also in this scenario we implicitly have an Environmental Tax Reform (ETR).

IMPACTS IN EU IN 2050



CO₂ emissions
(-76% compared to 1990)



RMC_{abiotic} reduced to
5.0 tons per capita



Cropland use per capita
(-31% compared to 2000)



Water exploitation index
below 20% in all EU
regions



GDP +12.4% (compared
to the Business-as-Usual
scenario)



3.5 million more jobs
(compared to the Business-
as-Usual scenario)

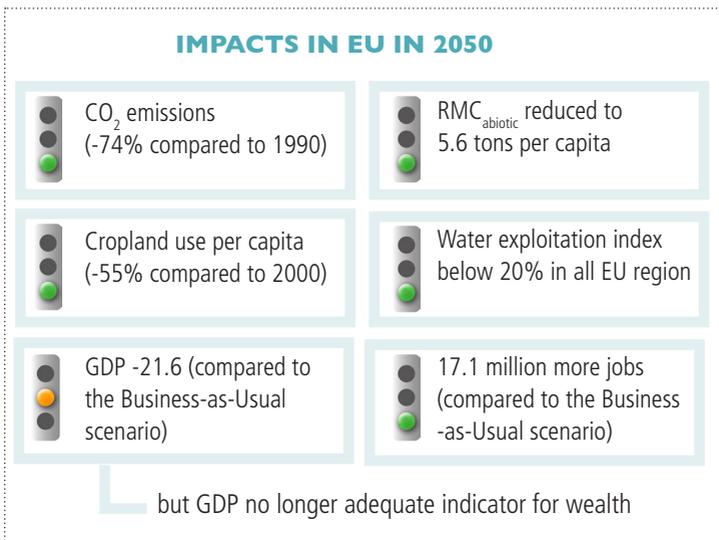
Conclusion 5

A strong post-consumerism movement in civil society may also drive resource-efficiency

The Civil Society Leads scenario assumes that instead of driving changes in resource efficiency through instruments as implemented in the EU Goes Ahead scenario, intrinsic motivation of consumers, employees and firms induces structural change of the economy to such a degree that the ambitious environmental targets are achieved. Several activities change the structure and volume of consumption, reducing environmentally harmful commodities like consumer durables, high-carbon, material-intensive transport and meat consumption. Further, employees seek to reduce hours worked in the formal economy, inducing an increased share of part-time employment in order to have more time for the family, engagement in society, volunteering and leisure.

In this scenario, average consumption in the EU returns to 1995 levels. Exports remain at the level of the Business-as-Usual scenario, as they depend on the international competitiveness of the EU industries and economic development abroad, which both are largely independent of consumer behaviour in the EU. Investment follows GDP, producing zero annual growth of GDP for the EU by 2050. However, it is also assumed that this scenario emerges as a 'Beyond GDP' future in the EU, in which measures of progress are diversified beyond economic growth as currently defined. Imports fall drastically in comparison with Business-as-Usual, in line with GDP, meaning that the contribution of international trade to EU GDP continuously rises to 2050. The EU finances growth abroad.

Despite the significant reduction of GDP compared to the Business-as-Usual scenario, the impact on employment is positive (9% increase in the number of jobs by 2050). This is a result of the increase in part-time jobs and reduced working time per capita. In addition, this produces lower labour productivities and wages, so that the effect on jobs in the EU is larger than expected by a simple *ceteris paribus* assessment.



Further Reading

Distelkamp, M., Meyer, B., Moghayer, S. (2015): *Report about integrated scenario interpretation: Comparison of results*. Deliverable 3.7c POLFREE project.

Hu, J., Moghayer, S., Reynes, F. (2015): *Report about integrated scenario interpretation: EXIOMOD/LPJmL results*. Deliverable 3.7b POLFREE project.

Jäger, J. & Schanes, K. (2014). *Report on Scenario Formulation*. Deliverable 3.5. POLFREE project.

Meyer, B., Distelkamp, M., Beringer, Tim (2015): *Report about integrated scenario interpretation: GINFORS/LPJmL results*. Deliverable 3.7a POLFREE project.

O’Keeffe, M., Jäger, J., Hartwig, F., Armeni, C., & Bleischwitz, R. (2014). *Report on global governance for resource-efficient economies*. Deliverable 2.5 POLFREE project.

Wilts, H., v. Gries, N., Bahn-Walkowiak, B., O’ Brien, M., Busemann, J., Domenech, T., Bleischwitz, R., & Dijk, M. (2014). *Policy Mixes for Resource Efficiency*. Deliverable 2.3 POLFREE project.



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