EXIOPOL

# Top-down approach

## A new enviromental accounting framework using externality data and input-output for policy analysis

# EXIOPOL // Top-down approach

This publication summarises the main results of the EXIOPOL research project: “A new environmental accounting framework using Externality Data and Input-Output tools for policy analysis”, sponsored by the European Commission from March 2007 until October 2011.

The present publication is divided into two parts: the front side is dedicated to the "EXIOPOL Top-Down approach", while the reverse side is dedicated to the "EXIOPOL Bottom-Up approach".

## Partners’ institutions participating in EXIOPOL

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SIXTH FRAMEWORK PROGRAMME

The research project EXIOPOL “A new environmental accounting framework using Externality Data and Input-Output tools for policy analysis” (2007-2011) is sponsored by the European Commission under the Sixth Framework Programme (Project n° 037033-2).

# EXIOPOL
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# EXIOPOL // Top-down approach

EXIOPOL has constructed a detailed, transparent, harmonised, global Multi-Regional Environmentally Extended Input-Output Table with externalities, called EXIOBASE, with the following characteristics:
• Covering 43 countries (95% of the global economy) and the Rest of World (combining the remaining 150+ countries)
• Full trade matrices with insights on which product from which country is exported to which industry sector in another country
• Distinguishing 129 industry sectors and products
• Covering 30 emitted substances and 80 resources by industry
• Extensions aggregated to compile indicators such as Global Warming Potential, Acidification, Total material requirement, and external costs. The latter were calculated by assessing the external costs of a kg per gas emission of a specific substance by a specific industry in a specific country, considering population density, rural or urban location, and stack height related to the emission.

The top-down approach developed in EXIOPOL considered the following questions, which were answered with the help of the EXIOBASE database:
1. What are the external costs of global economic production?
2. What are the impacts embodied in European imports?
3. What are the dynamic impacts of policy interventions in the following areas: buildings, mobility, and food?

**External costs and Impacts of European consumption and impacts embodied in European imports**
The external costs generated by our current economic system are significant. Considering that the global GDP was € 34.1 Trillion in 2000, the estimated external costs amounted to € 2.35 Trillion. The externality assessment in our study is far from complete, neglecting, for instance the value of ecosystem services and biodiversity. Nevertheless, the impacts included (emission related alone) create an amount of damage costs equivalent to 7% of the global GDP. Respiratory health effects (€ 1,5 Trillon) and energy-related climate impacts (€ 0.6 Trillion) form the dominant contributions to these external costs.

Considering the impacts of European consumption as well as the impacts embodied in European imports and exports, Europe is generally a net importer of natural resources and pollution.
• This is particularly true for land and water. The land use embodied in trade is higher than the land use in Europe itself ( more than half of the land use for the final demand in Europe is imported).
• There are also significant material imports embodied in trade.
• The flows that are embodied in imports and exports are relatively close for energy and greenhouse gases.
• External costs are the only factor for which Europe is a net exporter. This is mainly because external costs (for instance, the value of a life) in the EXIOPOL approach are related to a country's wealth. This implies that external costs related to the same impact are valued lower outside Europe rather than inside Europe.

**Dynamic impacts of policy**
EXIOBASE has also been used in a dynamic form. Scenarios were imposed on the Environmentally Extended Input-Output database in combination with the World Trade Model. The aim was to analyse implications of certain policy actions. The main findings include:
• Implementation of the Directive 2002/91/EC on the energy performance of buildings can reduce GHG emissions by 150 Mtons in 2050.
• Scrappage premiums for old cars in combination with tax incentives stimulate car sales with low $CO_2$ emissions, which greatly reduce the $CO_2$ emissions of cars themselves. Impacts on employment and value added are limited in most scenarios.
• Diet changes towards a Mediterranean diet with lower meat consumption reduces impacts in land use, water use, and to a lesser extent GHG emissions. When diet change is combined with the reduction of food losses, higher reductions in impacts occur (22% less water use, 18% less land use, and 2.2% less GHG emissions). In the various scenarios agricultural employment will diminish by 2-3%.

# Policy analysis using Top-Down approach

This Policy Brief presents the use of EXIOBASE in dynamic form, first calculating **scenarios for Sustainable Consumption and Production for the EU**, and then calculating **global scenarios for agriculture**.

## Buildings, transport and food (IPTS and NTNU)

### General methodology

EXIOPOL provided a detailed, transparent, harmonised, global Multi-Regional Environmentally Extended Input Output (MRIO) database with externalities, called 'EXIOBASE'. With this database, various dynamic analyses were performed. The Institute for Prospective Technological Studies (IPTS) imposed several strong European Sustainable Consumption and Production (SCP) policy scenarios on the database in the areas of buildings, transport, and food. The Norwegian University of Science and Technology used the database for analyses of global food and agriculture scenarios within the World Trade Model.

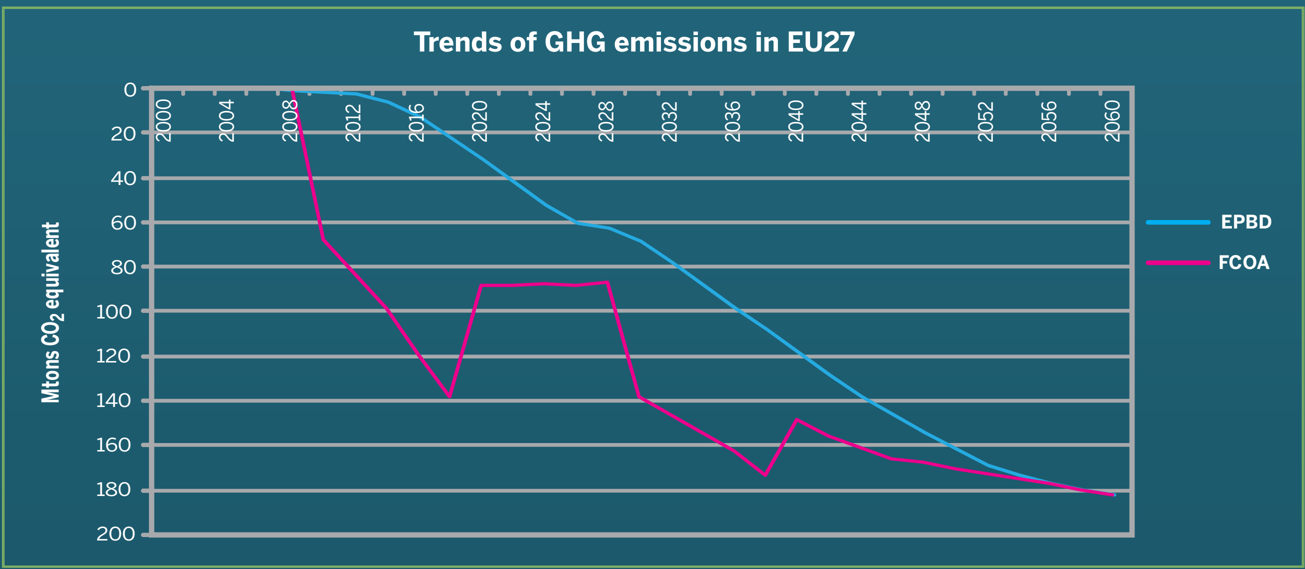
### Buildings

#### Methodology

IPTS developed two main scenarios. In the first one, the Directive 2002/91/EC on the Energy Performance of Buildings (EPBD) is the starting point: it assumes that from 2017 onwards, the level 3 energy efficiency is applied to all construction and major renovation activities. In the second scenario, it is assumed that from 2009 onward, all the renovation and refurbishment activities attain a cost-optimal energy efficiency level (Full Cost Optimisation Analysis - FCOA). It is possible to achieve faster and significant $CO_2$ reductions in scenario 2. These scenarios have been imposed on the EXIOBASE MRIO model[1].

#### Results

As shown in the figure below, both scenarios lead to significant reductions of GHG emissions in the EU27. Note that it concerns economy-wide impacts, including the GHG impacts of construction and renovation activities themselves. Furthermore, what would be the impact of the energy efficiency measures on imports from abroad (due to imports of energy-efficiency equipment)? This appears to result in a slight reduction of $CO_2$ emissions outside the EU. The EU imports less energy carriers, and hence related $CO_2$ emissions from extraction activities are avoided.




[1] The MRIO model used in this study has been previously proposed in Kratena and Streicher (2008) and is based on the Stone model described in Pyatt (1994). Kratena, K. and Streicher, G (2008). 'Macroeconomic Input-Output Modelling– Structures, Functional Forms and Closure Rules'. International Input-Output Association, Working Papers in Input-Output Economics, WPIOX 09-009. Pyatt, G. (1994), Modelling Commodity Balances: A Derivation of the Stone Model. The Richard Stone Memorial Lecture, Part I, Economic Systems Research, 6(1), pp. 5-20.

# Transport

## Methodology

For the transport sector, three scenarios were analysed:
1. **Scenario 1**: a feebate system that stimulates car sales with low carbon emissions, combined with a € 1,000 scrappage fee for old cars
2. **Scenario 2**: a tax system imposed on cars with high carbon emissions, combined with a € 3,000 scrappage fee for old cars
3. **Scenario 3**: a feebate system stronger than the one considered in Scenario 1, again combined with a € 1,000 scrappage fee for old cars.

Each of these scenarios implied changes in different categories of final demands such as fuel, vehicles, insurances, among others. The MRIO model was used to explore the socioeconomic and environmental indirect effects of these variations (excluding use phase impacts).

## Results

The increase of GHG emissions in the EU depends mainly on the production of steel, which is used to manufacture new cars. The growth in the demand for new cars in EU27 generates an increase in the production of cars and components in the 'rest of the world'. Yet, there is a reduction in the demand for oil and oil products, which is much more capital intensive than the car industry. Therefore the increasing car demand does not compensate the value added reduction because lower capital use occurs in the sectors related to oil extraction and oil production.

**Cumulative change with respect to the Reference scenario for EU27 (%)**

| Scenario | Value Added | Employment | Energy Use | Biomas | Unused Biomass | Water | Land | GHG emissions | Acidifying Emissions |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.76 | 1.04 | -8.38 | -1.67 | -1.65 | -1.20 | -1.11 | 0.25 | -0.53 |
| 2 | -0.37 | 0.67 | -17.51 | -14.58 | -14.88 | -14.40 | -12.03 | 1.08 | -6.49 |
| 3 | 1.06 | 1.43 | -11.46 | -2.19 | -2.16 | -1.50 | -1.43 | 0.31 | -0.69 |

**Cumulative change with respect the baseline Rest of the World (%)**

| Scenario | Value Added | Employment | Energy Use | Biomas | Unused Biomass | Water | Land | GHG emissions | Acidifying Emissions |
|---|---|---|---|---|---|---|---|---|---|
| 1 | -0.30 | 0.00 | -0.40 | -0.22 | -0.26 | -0.30 | -0.19 | -0.16 | -0.30 |
| 2 | 0.00 | 0.15 | -0.12 | -0.22 | -0.54 | -0.15 | -0.13 | 0.40 | 0.07 |
| 3 | -0.45 | -0.15 | -0.55 | -0.31 | -0.36 | -1.50 | -0.26 | -0.23 | -0.30 |

# Food - European scenarios

## Methodology

Four diet scenarios were analysed for the EU:
1. **Scenario 1 Mediterranean composition**: the dietary profile of each Member State is adjusted to reflect the composition of the Mediterranean diet. The kCal level of the diet remains to the same as the benchmark.
2. **Scenario 2 Mediterranean diet**: the dietary profile of each Member State is adjusted to reflect both the food item composition and the kCal level of the Mediterranean diet.
3. **Scenario 3 Mediterranean diet with -50% of red meat**: the dietary profile is the same as the one simulated in Scenario 2, but red meat intake is reduced by 50%.
4. **Scenario 4 Mediterranean diet with -50% of red meat and a -14% of average food end-use losses**: in addition to what is foreseen in Scenario 3, Scenario 4 assumes a better purchasing decision and storage process by the households which permit the reduction of end-use losses by 14% and an implicit reduction of purchased food.

## Results

For all the scenarios considered in this study, most of the variables show a reduction. The results reported the 'rest of the world' are largely smaller than the variations measured for EU27. Most of the food value chain is located inside the EU and, therefore, these scenarios have little trade related impacts.

**Percentage variations (%) from baseline year – Diet Change, EU27**

| Scenario | Value Added | Employment | Energy Use | Biomas | Unused Biomass | Water | Land | GHG emissions | Acidifying Emissions |
|---|---|---|---|---|---|---|---|---|---|
| 1 | -0.26 | -2.53 | -0.75 | 1.84 | 7.59 | -2.38 | -5.45 | -0.60 | -1.84 |
| 2 | -0.27 | -2.56 | -0.76 | 0.03 | 5.61 | -3.06 | -6.62 | -0.85 | -2.40 |
| 3 | -0.25 | -2.66 | -0.63 | -2.90 | 3.63 | -5.73 | -7.59 | -1.86 | -7.74 |
| 4 | -0.24 | -2.86 | -0.64 | -15.16 | -16.03 | -22.03 | -18.66 | -2.24 | -6.36 |

**Percentage variations (%) from baseline year – Diet Change, Rest of the World**

| Scenario | Value Added | Employment | Energy Use | Biomas | Unused Biomass | Water | Land | GHG emissions | Acidifying Emissions |
|---|---|---|---|---|---|---|---|---|---|
| 1 | -0,003 | 0,042 | 0.00 | 0.13 | 0.42 | 0.05 | 0.10 | 0.02 | 0.04 |
| 2 | -0,004 | 0,031 | -0.01 | 0.10 | 0.35 | 0.04 | 0.08 | 0.01 | 0.03 |
| 3 | -0,022 | -0,015 | -0.03 | -0.02 | 0.13 | -0.05 | -0.03 | -0.03 | -0.05 |
| 4 | -0,038 | -0,088 | -0.04 | -0.17 | -0.36 | -0.13 | -0.12 | -0.05 | -0.08 |

# Food - Global scenarios

## Methodology

The World Trade Model (WTM) was used to analyse the following three scenarios: E2000, E2050, and ETD. The first scenario is a baseline calculation for the year 2000 using the EXIOPOL variables and parameters and serves as the reference point to compare the outcomes of the other two scenarios.

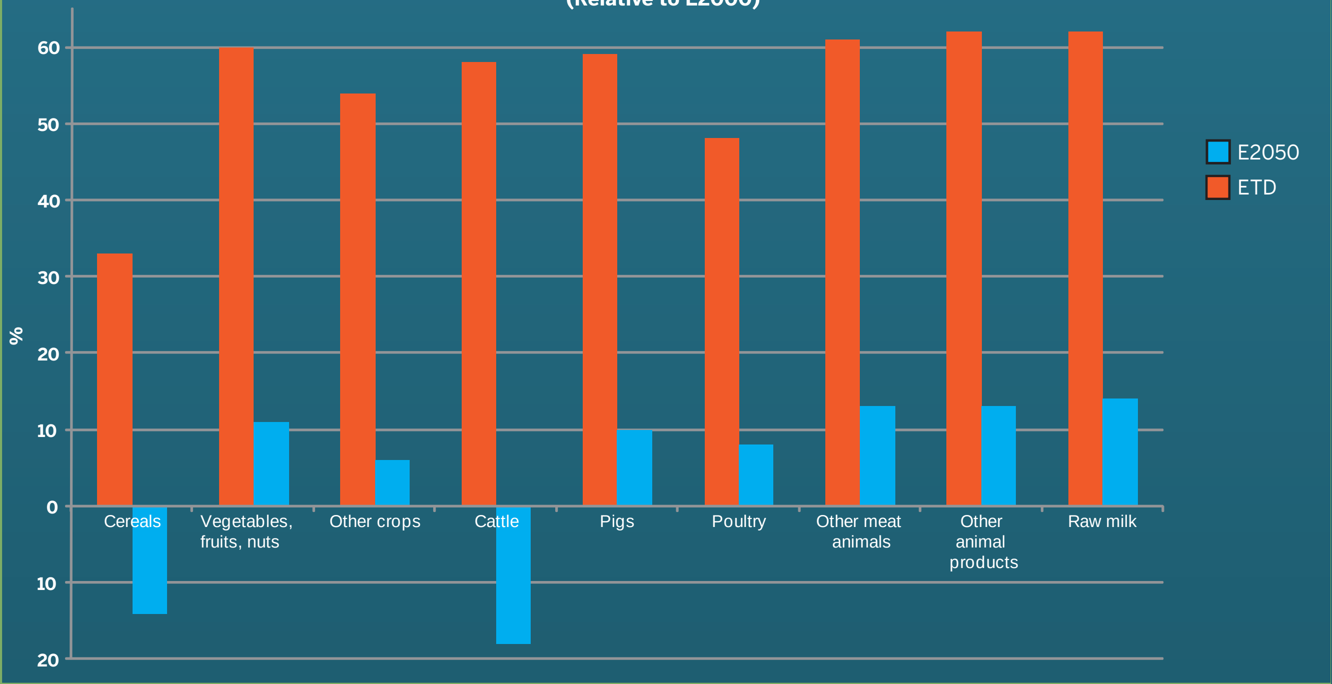
The second scenario, E2050, assumes growth in all components of demand over the next four decades. It is proportional to regional population growth projections, and assumes increases both in caloric intake and especially access to animal products within developing countries.

The final scenario, ETD, is designed to analyse wether pressures from the second scenario can be alleviated by adopting less resource-intensive diets in the rich countries, where they are accompanied by the improved management of water and less land-intensive livestock technologies.

## Results

The results of the simulation show that there will be enough land and water to feed 9 billion people  as well as improve diets in developing countries. However, the following should be considered:
(a) The prices of foods will increase steeply (30-100%)
(b) Irrigation will be reserved for high-value crops with grain almost entirely rainfed
(c) Large amounts of additional land in Africa and Latin America will be cultivated
(d) The EU will specialise in the production of higher-value food products and increasingly import commodity foods such as grains
(e) The scenario, which reduces animal-product content from  rich-country diets and adopts well-defined measures to improve agricultural productivity in Africa and Latin America can succeed in lowering food prices to 10-15% above the baseline

**Percentage change in agricultural commodity prices under WTM/EXIOPOL Scenarios**
**(Relative to E2000)**



# Key findings from EXIOPOL Top-Down estimates

This Policy Brief presents the use of EXIOBASE in static form, analysing **the pollution related to imports and exports to and from Europe.**

## Impacts from imports and exports (TNO and NTNU)



### Methodology

EXIOBASE contains over 100 extensions (emissions and resource uses): we used a number of well-known indicators that express all resource uses and emissions[1] in a more aggregated form. These include:
- Life cycle impact assessment indicators, most notably Global Warming, Acidification, and Eutrophication: these indicators aggregate substances emitted according to the type of impact
- Material flow indicators, most notably Total Material Requirement: this indicator simply adds up all resource extractions in tons
- Land use: this indicator simply calculates the land occupation (mainly for agricultural products and forestry)
- Water use: 'blue' water (ground and surface water) and 'green' water (rainwater)
- External cost factors were calculated per kg of emission per type and by industry, taking into account specificities such as: the average population density in a country, and wether the substance is emitted from a very low, low, or high stack (which has implications for how far emissions are distributed). These cost factors mainly relate to air emissions.

EXIOBASE covers the global economy. Hence it is possible to analyse the impacts of policies and measures throughout the European territory, as well as the impacts outside Europe related to imports by Europe and impacts in Europe for products exported to outside Europe.

### Results

The overall picture is that Europe is a net importer of natural resources and pollution.
- This is particularly true for land and water. The land use embodied in trade is higher than the land use in Europe itself (more than half of the land use for the final demand in Europe is imported).
- There is also a significant amount of material imports embodied in trade.
- The flows that are embodied in imports and exports are relatively close for energy and greenhouse gases.
- External costs are the only factor for which Europe is a net exporter.

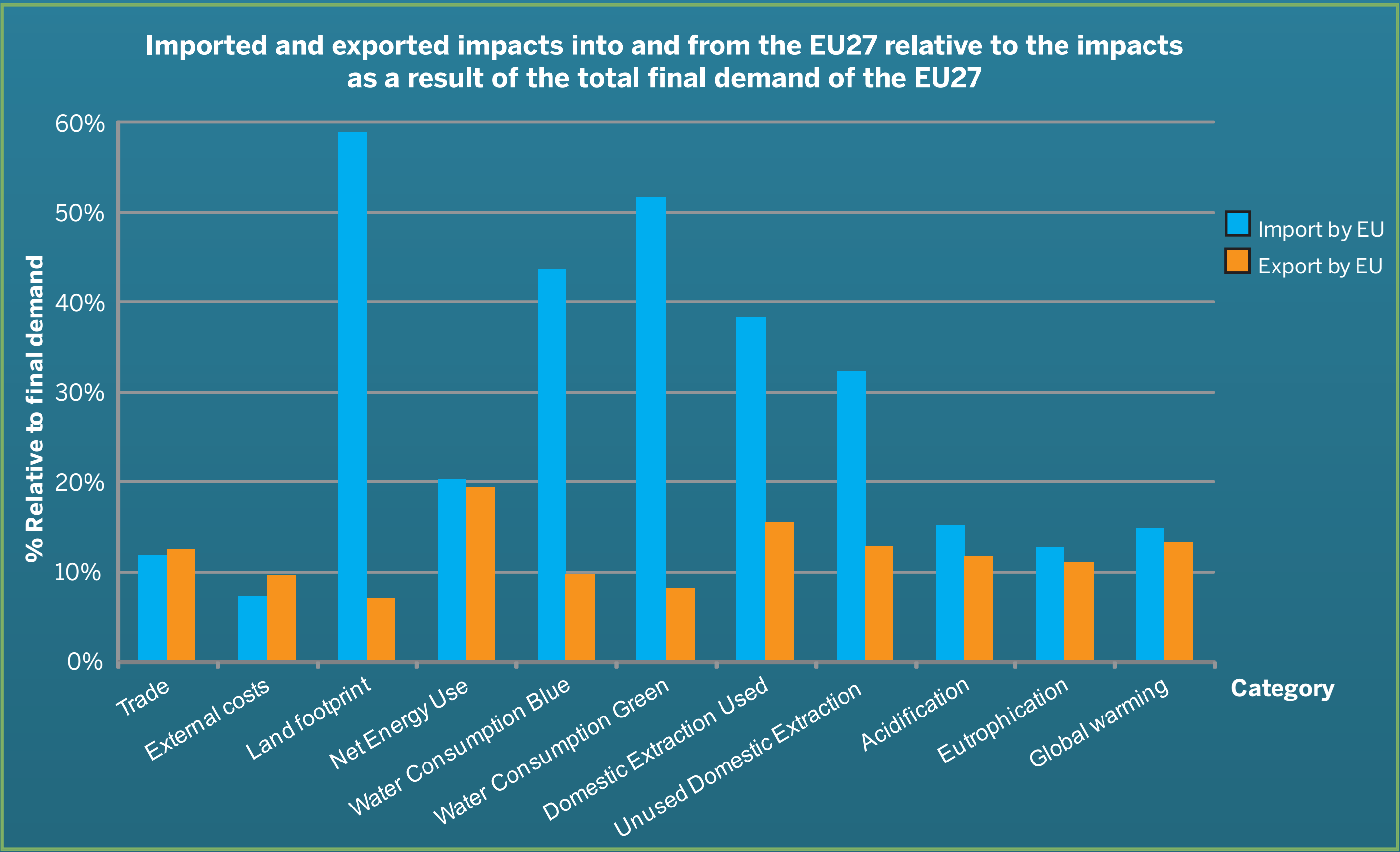
Impacts per capita related to EU27 final demand* in 2000, as well as impacts related to EU27 imports and exports per capita

| Impact type | Unit | Final demand/cap | Import/cap | Export/cap |
|---|---|---|---|---|
| External costs | Euro | 1191 | 86 | 115 |
| Land footprint | $km^2$ | 1,7 | 1,0 | 0,1 |
| Net energy use | GJ | 113 | 23 | 22 |
| Water consumption blue | $m^3$ | 767 | 335 | 75 |
| Water consumption green | $m^3$ | 4446 | 2301 | 367 |
| Material extraction used | Ton | 17,0 | 6,5 | 2,6 |
| Unused material extraction | Ton | 13,8 | 4,5 | 1,8 |
| Acidification | kg $SO_2$ eq. | 64,2 | 9,8 | 7,5 |
| Eutrophication | kg $PO_4$ eq. | 8,2 | 1,0 | 0,9 |
| Global Warming Potential | Ton $CO_2$ eq. | 12,5 | 1,9 | 1,7 |

* Assuming an EU27 population of 483 Million in 2000 (Eurostat)

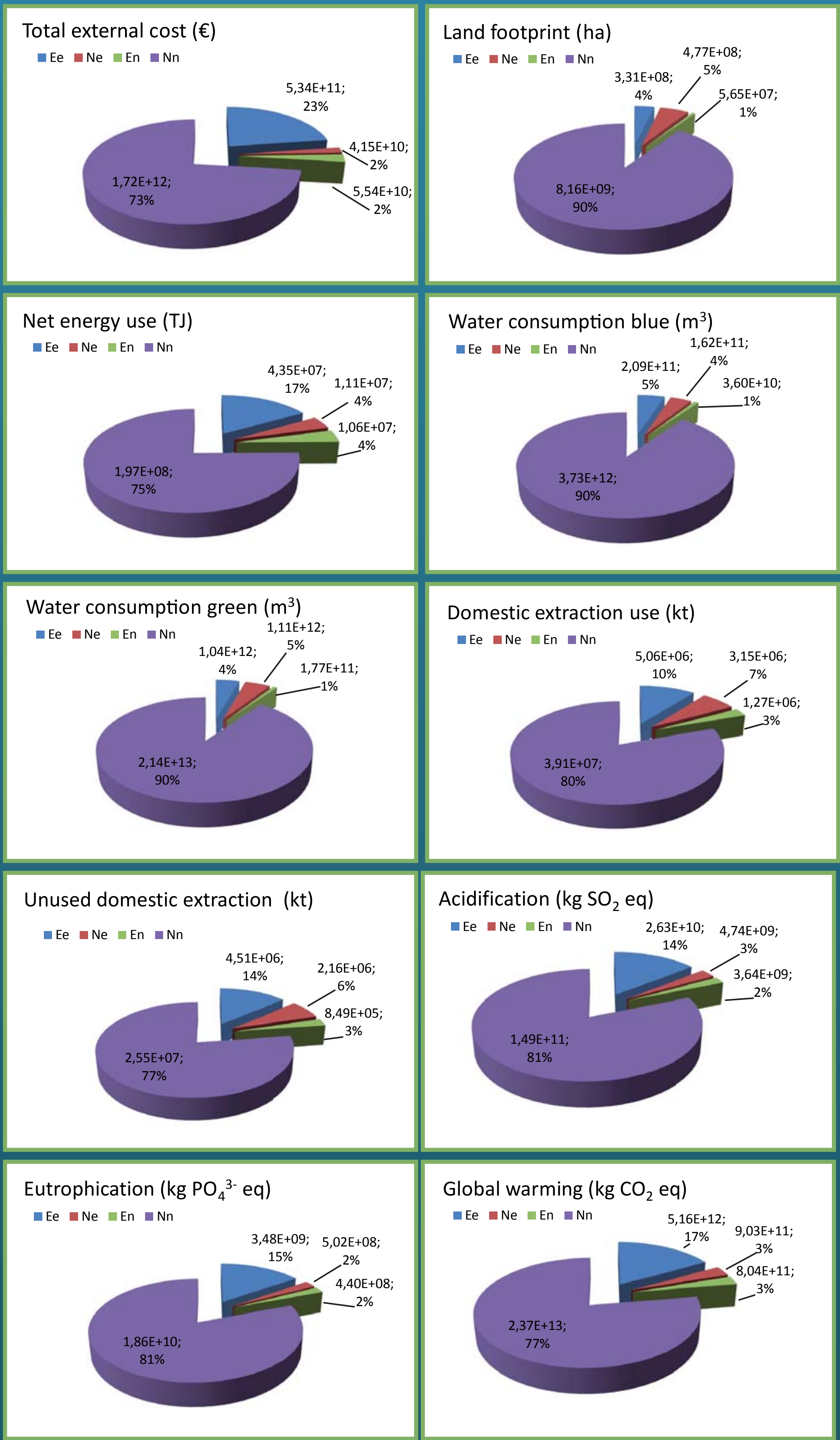
[1] Currently air emissions from the Rest of World are not covered by EXIOBASE. Land use, water use, and material extractions from the Rest of World are included.

The main reason for this is probably that externalities in economies that have a lower wealth tend to count for less in value terms. For non-EU countries, due to the lack of data, the European external costs were adjusted according to the Purchasing Power Parity index. Particularly the densely populated and fast developing economies outside Europe (China, India), have relatively low PPPs, implying that (health) damage is not as substantial as it is in Europe, in the approach used. This is obviously a relatively subjective assumption, which can be  examined from an ethical perspective. The issue of how to deal with the relative value of damages to human health, ecosystem health, and economic production in rich and poor countries is, in our view, an important issue of future research for the externality community.




A striking discovery of this study is that the external costs created by our current economic system are significant. The global GDP was € 34.1 Trillion in 2000, and the estimated external costs amounted to € 2.35 Trillion. The externality assessment in our study is far from complete, neglecting, for instance the value of ecosystem services and biodiversity. The emission related impacts included in our study alone create an amount of damage costs, which represent 7% of the global GDP, mainly due to climate impacts and the respiratory health effects.

## Territorial impacts in the EU27 and non EU27 and the impacts on these territories for exports to the non EU27 and EU27 respectively




**Ee)** emissions within the EU as a result of the final consumption of the EU.

**Ne)** emissions outside the EU as a result of the final consumption of the EU which might be labeled emission embodied in imports to satisfy EU final demand.

**En)** emissions within the EU as a result of the final consumption of non-EU countries which might be labeled as emissions embodied in exports of the EU.

**Nn)** emissions outside the EU as a result of the final consumption of the non-EU countries.