EXIOPOL

a new environmental accounting framework using externality data and input-output tools for policy analysis

EXIOPOL: summary of the project

Anil Markandya, BC3

Luxembourg, October 12th 2011

EXIOPOL overview

- EXIOPOL research project: “A new environmental accounting framework using Externality Data and Input-Output tools for policy analysis”
  - sponsored by the European Commission under the 6° framework programme
  - from March 2007 till October 2011
  - involving 36 partners
- The EXIOPOL IP had 3 principal objectives:
  - To synthesize and develop comprehensive estimates of the external costs for Europe of a broad set of economic activities;
  - To set up a detailed environmentally extended (EE) Input-Output (I-O) framework, with links to other socio-economic models, in which as many of these estimates as possible are included. Such an EE I-O table for the EU 25 does not exist. This will allow for the estimation of environmental impacts and external costs of different economic sector activities, final consumption activities and resource consumption for countries in the EU;
  - To apply the results of the external cost estimates and EE I-O analysis for the analysis of policy questions of importance, as well as to evaluate the impact of past research on external costs on policy-making in the EU.

Expanding and synthesizing the database on environmental costs within the EU

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EXIOPOL Bottom-Up approach

- EXIOPOL was a key contributor in expanding and synthesising a database on the costs of environmental burdens within the EU, measured in monetary terms.
- EXIOPOL analysed the treatment of risks, of threshold effects, the valuation of non marginal externalities and rules for aggregation…
- … and evaluated, analysed, and assessed damages from the emissions of pollutants into air and water. The project updated and detailed external costs by type of emission and country, as well as for a range of themes, the principals being:
  - Mortality risks
  - Pesticides in agriculture
  - Nutrients in agriculture
  - Biodiversity
  - Forestry
  - Steel industry
  - Wastes
- Lastly, the Bottom-Up approach within EXIOPOL analysed two **Policy Case studies under different scenarios in 2020**.
  - Agriculture
  - Energy
- Each of the themes listed above, and the two Policy case studies, correspond to **a different sheet in the Bottom-Up set of Briefs** that has been distributed today, and available on the project's website.
- I will present briefly the **Key findings from EXIOPOL Bottom-up estimates**, leaving the floor to individual Partners to answer questions coming from the public, while Rainer Friedrich will present after me the **Policy analyses performed within EXIOPOL using Bottom-Up approach.**

Mortality risks

- The benefits of environmental policies and regulations that reduce premature mortality are **typically calculated as the number of Lives saved by the program multiplied by the Value of a Prevented Fatality** (VPF), also known as the Value of a Statistical Life (VSL), a summary measure of the Willingness To Pay for mortality risk reductions.
  - Concerns have been raised about the appropriateness of much policy practice today, which uses compensating wage studies or literature about transportation accidents to calculate the VPF.
  - Some academic and policy circles propose an alternate approach to valuing the mortality benefits of environmental policies, which requires computing **life expectancy gains (losses) and multiplying them by a metric known as the Value of a Statistical Life Year** (VOLY). Until recently, however, most estimates of the VOLY were derived from estimates of the VSL, which, in turn were taken from labor market studies.
- The EXIOPOL surveys on mortality risks were conducted in Italy, the UK and the Czech Republic. They employed conjoint choice experiments because this technique allows us to study how people respond to variations in the attributes of the risks being valued, to the cause of death, and to the risk context (environmental exposures v. others).
- The study incorporated **several methodological treatments in our questionnaires**, including the use of follow-up conjoint choice questions, and comparisons between internet-administered (CAWI) and computer-assisted in person interviews (CAPI), which we hope will provide useful information for future research.

Mortality risks

- Briefly, we find that the VSL (averaged across all variants of the questionnaire within a country) is € 2.273 Million in Italy, € 0.877 Million in the UK and about € 2.183 million in the Czech Republic.
- **However, there are sharp differences in the VSL estimates when we do and we do not inform people about the life expectancy gain implied** by the risk reductions shown to them in the conjoint choice questions.
  - When no such mention is made, the VSL is typically much larger: It is about € 5.766 million in Italy, € 6.254 in the UK, and € 4.252 million in the Czech Republic. These figures are comparable to those estimated in earlier DG funded projects where respondents examined mortality risk reduction profiles, and are slightly higher than the VPF figures commonly used by DG-Environment in its policy analyses.
  - When respondents are informed about realistic life expectancy gains associated with the risk reductions they are to value, the VPF is only € 0.220 million in Italy and € 1.096 million in the Czech Republic.
  - When respondents are told about somewhat “inflated” life expectancy gains, the VPFs are € 0.562 million (Italy), € 0.136 million (UK) and € 1.531 million (Czech Republic).
  - The impact of the life expectancy extension reminders is especially strong in the UK. This effect cannot be attributed to income, since the UK sample was wealthier than the Italy and Czech samples and had the highest VPF when no mention of life expectancy gains was made.
- The study also found that people have **higher VSL values when the risk being reduced are those associated with environmental exposures**, and it found **no difference in the VSL by cause of death**.
- These results are potentially very important for policy purposes. Regarding the effects of environmental risks, we believe that people are willing to pay more to reduce these risks because they perceive them as involuntary. By contrast, others risks such as transportation risks or risks associated with lifestyle are often perceived as voluntary and controllable.

Biodiversity

- EXIOPOL reviewed multiple experiences of biodiversity preservation around the world, and studied citizens preferences towards various hypothetical conservation policies assessed in surveys using stated preferences techniques. Two different questionnaires were designed to study citizens' preferences in the EU towards various biodiversity conservation policies.
  - The first survey was conducted in a sample of Italian households to assess citizens' preferences towards the recovery of traditional rice landscapes and plantation techniques in the Pavia area.
  - The second panel survey was conducted via internet in the UK, Spain, and Italy. This survey collected opinions regarding a common biodiversity policy that would be implemented in the respective countries. Its focus is on traditional cereal cultivation techniques, which aim to increase biodiversity levels, cultural heritage, and other related services.

Biodiversity

- The biodiversity services valued in the first survey are related to the recovery of traditional rice landscapes and plantation techniques. Among these services, mosquito reduction is valued as the most important service for the respondents.
  - The highest value associated with the reduction of mosquitoes would imply that stressing more direct-use anthropocentric-related benefits in the biodiversity policies might encourage more support from people with different environmental attitudes.
- The second survey developed in the UK, Spain, and Italy used a payment reallocation mechanism by which individuals would be able to redistribute existing funds towards the preservation of biodiversity. The study found that preferences of European citizens diverge considerably with respect to biodiversity preservation and their valuation or ranking of the evaluated services.
  - In particular, Spanish and Italian citizens are more likely to reallocate the current public budget and forego some of the current public services to enhance agricultural areas and biodiversity.
  - On the other hand, UK citizens are not likely to reallocate the existing public budget to enhance biodiversity protection and in particular to preserve insect population and cultural heritage services.

- As it is well known, in agriculture biodiversity, loss is exacerbated due to two main trends: a) abandonment of marginal lands, and b) intensification activities in productive lands. Although biodiversity generates many benefits, including environmental externalities and economic benefits, the general public appears not to be fully aware of such benefits.
  - It is important that citizens fully understand the key role played by biodiversity, to properly assess values to its multiple functions and services This is most likely the case with more intangible services, such as the pollination benefits that citizens are not willing to support, probably due to the association with the existence of insects that have other negative externalities.
  - Preferences appear to be heterogeneous across countries. Thus, a common payment for ecosystem services (PES) may have to vary across countries to properly reflect such heterogeneous preferences.
  - While in the Southern European countries, survey participants are willing to support the cultural heritage services linked to biodiversity preservation, such priority or concern does not strongly emerge in the UK.

Pesticides in agriculture

- EXIOPOL has quantified the **effects of pesticides - herbicides and insecticides - application at the EU level**:
  - for human health, trough the ingestion pathway, that is, the **consumption of harvested and processed agricultural products**
  - for ecosystems, as a result of the **fraction of an applied pesticide that undergoes run-off** from soil to surface water, or **leaching** from surface soil to sub-surface soil and further to the groundwater table

Pesticides in agriculture

- EXIOPOL began with the **inventory of the five most extensively applied pesticides** for each country, leading to a short list of all substances of concern, which were then classified and aggregated to finally be able to cover the vast majority of used pesticides.
- A **new dynamic modelling approach** was developed to provide a better understanding of the complex behaviour of pesticides in the plant-environment system. It allows the estimation of residues in food products effectively harvested and processed for human consumption.
- From these, the **human intake fraction** [$kg_{intake}/kg_{applied}$] was combined with the total mass of applied pesticides in each country, to arrive at human health effects in terms of unit values.
- The fraction of applied **pesticide that is lost to the environment** serves as basis for arriving at ecosystem effects, in terms of potentially affected fractions of species for each considered country.

Pesticides in agriculture

Unit values for human health aggregated over the whole agricultural sector and all human health end-points for the year 2000[5]

	Austria	Belgium	Bulgaria	Cyprus	Czech Republic	Germany	Denmark	Estonia	Spain	Finland	France	Greece	Hungary	Ireland
Insecticides [€/kg.yr]	100.6	227.6	n/a	0.7	161	1.1	1.8	0	258.3	372.5	0	300.3	437.8	111
Herbicides [€/kg.yr]	10.8	24.9	n/a	5.2	16.3	0	1.3	74.5	42.2	19.4	15.8	51.5	62.2	19.5

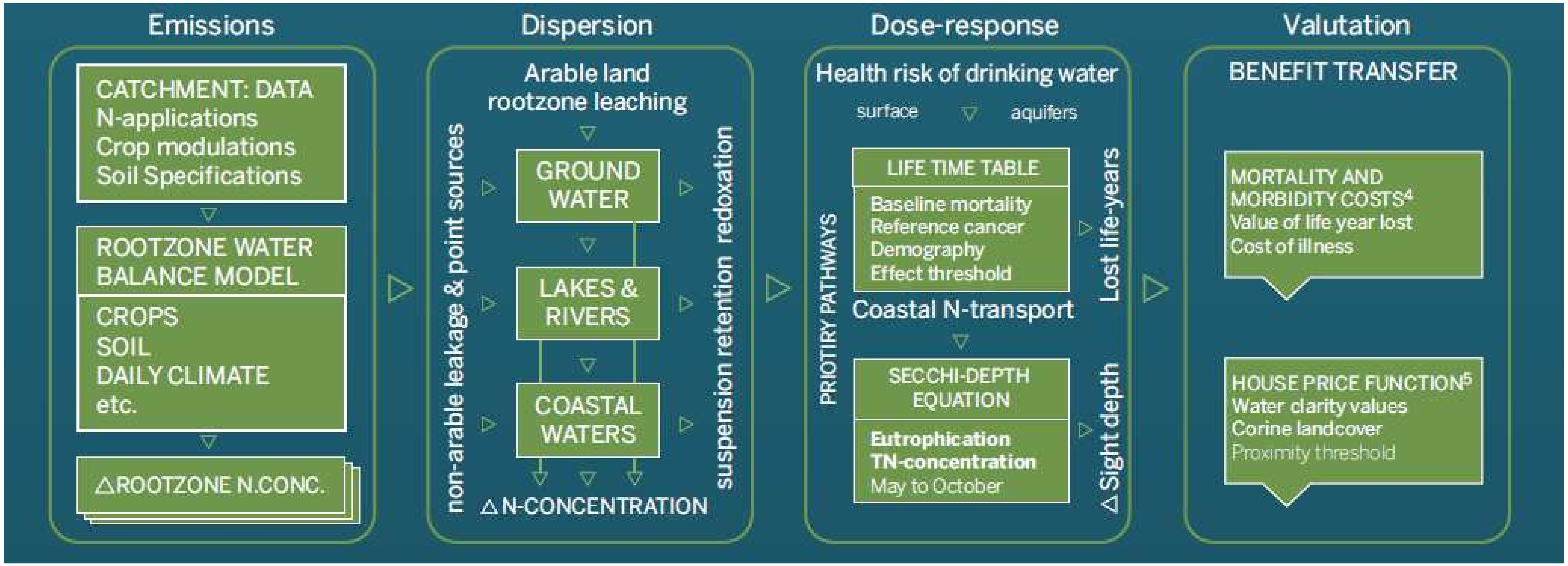
	Italy	Lithuania	Luxembourg	Latvia	Malta	Netherlands	Poland	Portugal	Romania	Sweden	Slovenia	Slovakia	United Kingdom
Insecticides [€/kg.yr]	1273	229.6	217.6	0	0	0	156.9	n/a	0	0.9	117.7	235.1	538.7
Herbicides [€/kg.yr]	47.3	35.5	23.3	34	0	22.2	19.9	n/a	61.6	0.6	31.3	33	53.8

Nitrogen fertilisers in agriculture

- EXIOPOL has quantified **external effects of nitrogen (mineral and organic) applications** in six European catchments **:**
  - for impacts on human health, the focus has been on the **intake with potable water** while
  - for ecosystems, the focus has been on **the fraction of applied nitrogen that reaches** surface waters and affects water clarity.

Nitrogen fertilisers in agriculture

- EXIOPOL builds on a calibrated nutrient modelling tool applied in previous EU funded research to most member states. Proceeding from a **meta-review of dose-response functions**, extensive modelling has been undertaken to explore implications of different scenarios of marginal changes in nutrients applications.
- Different aquatic recipients, as well as the weather, soil, and run-off conditions imply a range of different outcomes that are highly catchment-specific.
  - EXIOPOL has applied the 'impact pathway approach' as the analytical method in the area of water management. It can identify site-specific benefits associated with management measures by linking economic and hydrological data through consecutive modelling stages, allowing for monetization of specific end point effects.
- The damages of nitrate pollution have been explored within an IPA framework, in six European catchments for surface water quality as for the abstraction of drinking water, as described here:



Nitrogen fertilisers in agriculture

Illustrative estimates of average external costs of nitrogen per member state

Effect information corrected unit values aggregated over the whole agricultural sector and all human health end-points for potable water for the year 2000.

	Austria	Belgium	Bulgaria	Cyprus	Czech Republic	Germany	Denmark	Estonia	Spain	Finland	France	Greece	Hungary	Ireland	Italy	Lithuania	Luxembourg	Latvia	Malta	Netherlands	Poland	Portugal	Romania	Sweden	Slovakia	Slovenia	United Kingdom
Organic nitrogen in [€/(kg.yr)]	0.03	1.34	0.01	0.07	0.32	0.16	0.16	0.03	0.09	0.00	0.24	0.02	0.02	0.02	0.05	0.00	0.51	0.00	0.40	0.36	0.06	0.07	0.03	0.00	0.03	0.07	1.42
Mineral nitrogen in [€/(kg.yr)]	0.03	1.22	0.01	0.06	0.29	0.14	0.14	0.03	0.08	0.00	0.22	0.02	0.02	0.02	0.05	0.00	0.46	0.00	0.40	0.32	0.05	0.06	0.02	0.00	0.03	0.07	1.29

- These result from scaling pilot catchment characteristics, whereby several key factors are taken into account, including the share of surface water for potable water supply, the exceedence of nitrate limits as well as population density. Differences in leakage rates to groundwater aquifers according to soil types have also been taken into account.
- Certain member states (UK, Belgium) are more profoundly affected by nitrogen pollution than others, presumably due to their reliance on surface abstraction for potable water.

Forestry

- EXIOPOL focused first on the **identification and screening of main forest goods and services in the European Union.** In total over 200 forest goods and services were listed:
  - Wood and fuel wood, climate regulation (carbon sequestration), biodiversity protection (existence value), and recreation were identified as the most important forest goods at the EU level.
- Further, more than **200 valuation studies** have been reviewed and **almost 700 value estimates for different types of forest externalities** have been documented in a database for a number of countries.
- The vast majority of the reviewed studies focused on the valuation of recreation activities (110), while other types of studies represent a minority: forest conservation (23), biodiversity (19), Total Economic Value (6), carbon (5), aesthetics, afforestation, forest amenities (4), erosion, landscape (3), forest fire risk (2), forest wetland, health benefi ts, Use values, water (1).
- In the final step, EXIOPOL linked the monetary values of forests (goods and services) with their physical characteristics.

Forestry

Estimated mean values for wood and non-wood forest products, carbon and recreation (separately for unprotected forests and for forests protected for biodiversity) in € per hectare and year for European countries.

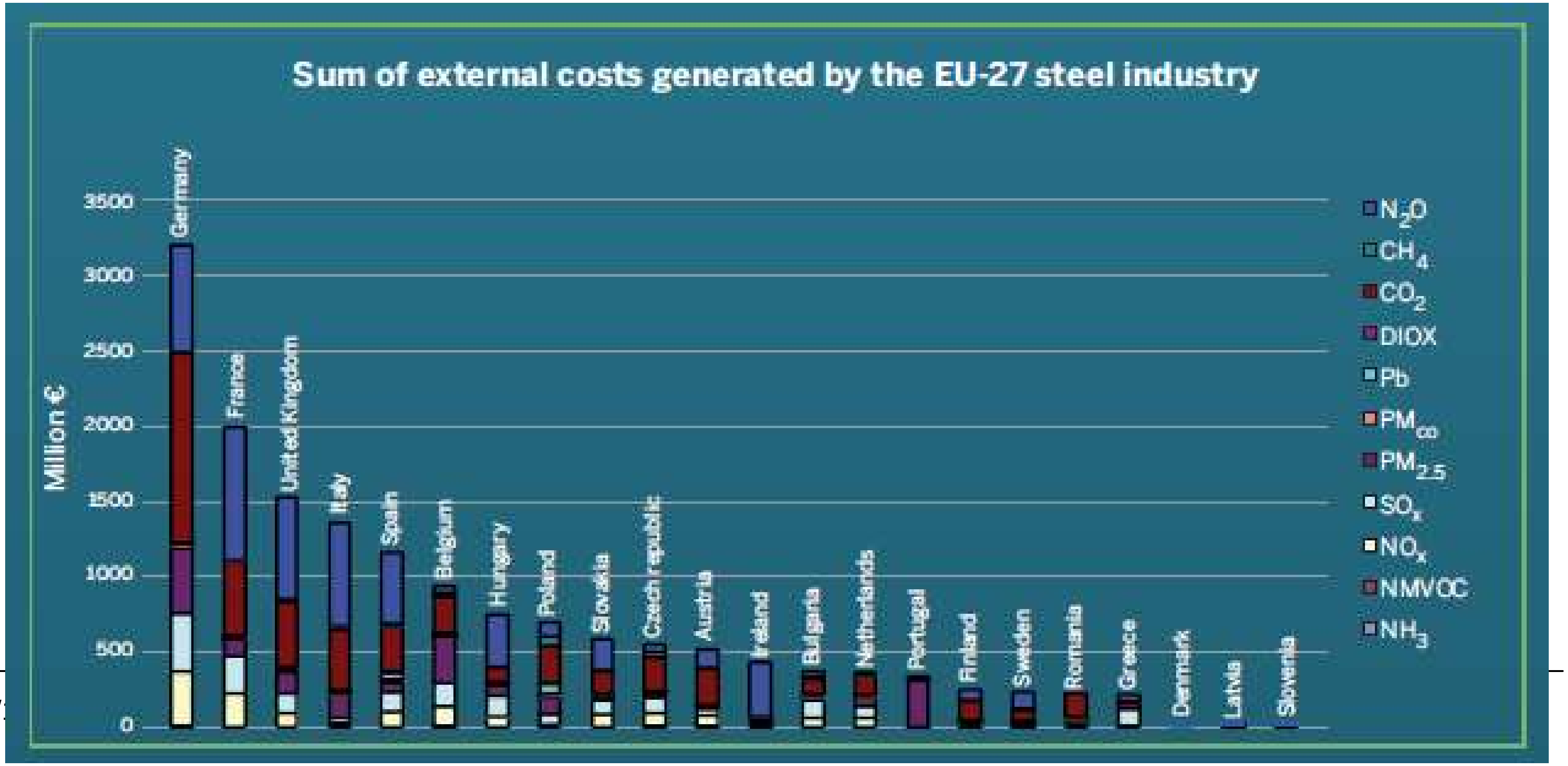
€ per hectare and year	Carbon	Wood and non-wood forest products	Recreation (unprotected forest)	Recreation (protected forest)
Austria	77.02	17.96	8.56	15.89
Belgium	64.20	21.57	25.58	47.48
Bulgaria	40.45	5.33	6.81	12.64
Czech Republic	32.56	20.7	11.50	21.34
Denmark	94.75	43.88	13.61	25.26
Estonia	9.98	6.58	2.71	5.03
Finland	21.78	8.31	1.53	2.84
Germany	92.48	20.28	17.24	32.00
Greece	14.86	1.63	7.01	13.01
Hungary	30.20	9.34	11.59	21.51
Ireland	15.10	29.01	10.68	19.82
Italy	130.78	11.92	14.92	27.69
Latvia	66.49	10.86	3.34	6.20
Lithuania	62.32	8.34	5.18	9.61
Luxembourg	0	8.78	13.48	25.02
Netherlands	108.87	13.62	31.47	58.41
Norway	63.93	4.97	2.16	4.01
Poland	69.995	10.88	10.77	19.99
Portugal	31.08	40.97	9.45	17.54
Romania	105.02	11.87	9.56	17.74
Slovakia	30.18	12.04	7.87	14.61
Slovenia	59.61	11.18	8.79	16.31
Sweden	11.94	12.46	1.94	3.60
Switzerland	19.48	18.76	16.64	30.88
United Kingdom	82.66	20.61	28.47	52.84

Steel industry

- The impacts on **ecosystem quality, human health, and climate change** from the steel industry were evaluated
  - for all **European countries** while
  - a second, more detailed study was performed for **Germany**.
- First, **data on the production of goods** from the manufacturing industry from Eurostat were combined with emission factors for the corresponding production processes from the Ecoinvent 2.0 life cycle inventory.
- Second, the damage potentials of the estimated overall emissions were estimated and applied for **ecosystem quality, human health and climate change**. This resulted in a list of **400 different pollutants** to be analysed.
- These were **transformed into monetary values** to identify the most relevant pollutants in an assessment of the industrial sector. A threshold of € 1 million was chosen to eliminate those with minor impacts, leading to the identification of **55 different relevant pollutants** within the Industrial sector.

European steel industry

- Emission data considered for the steel industry in Europe include: classical air pollutants, heavy metals, persistent organic pollutants (POPs) and particulate matter emissions, quantified over a grid of approximately 50x50km.
- The monetary valuation of these emissions was performed by the application of monetary damage factors to estimate the damages to human health, the loss of biodiversity, and damages to crops and the ozone from nitrate deposition.



German steel industry

- The EcoSenseWeb model provides a detailed assessment of externalities as well as the calculation of external costs within different countries based on the impact pathway approach developed in the ExternE project series.
- EcosenseWeb can perform an analysis of the endpoints of the **impacts on human health** with a differentiation of the cause of the impacts made by distinguishing between PM10 and SIA10 for cases of infant mortality, or for PM2.5 and SIA2.5 for ‘chronic’ YOLLs which can be compared to DALYs: these endpoints are then valued in monetary terms to obtain the external costs.
- To compare the results, **two different chemical transport models** have been applied in the study of the steel industry in Germany.
  - the aforementioned **EMEP model** based on a 50x50km grid and
  - the **Polyphemus model** with spatial emission data provided by the German Federal Environment Agency.

German steel industry

External costs generated by the German steel industry																														
Country	Germany	Netherlands	France	Poland	Belgium	United Kingdom	Czech Republic	Italy	Austria	Hungary	Denmark	Romania	Sweden	Slovakia	Spain	Slovenia	Bulgaria	Luxembourg	Greece	Lithuania	Finland	Latvia	Ireland	Portugal	Estonia	Malta	Cyprus	EU-27	other countries
M €	744.74	75.67	62.12	52.64	41.29	29.14	27.15	26.51	15.77	9.46	9.05	8.70	5.52	5.35	3.34	2.87	2.00	1.88	1.69	1.67	0.94	0.88	0.70	0.45	0.36	0.05	0.04	1129.98	67.56

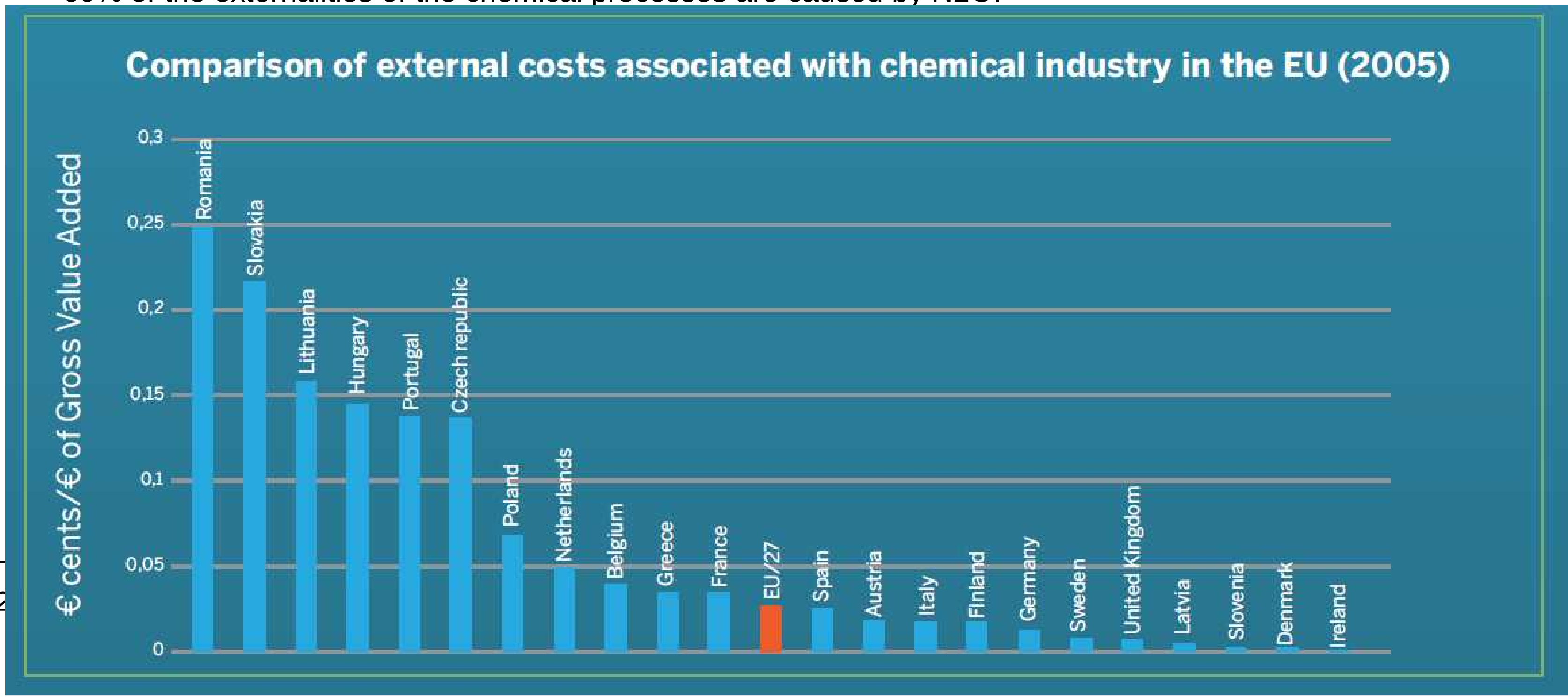
- At the German regional level, the west of the country faces the worst impacts, especially the Ruhr area where most of the mining and metal processing industries are located and which has the highest population density.
- In all of the four sub-regions analysed in Germany, more than 95% of the external costs result from damages to human health, the greatest share of which can be attributed to SO2 and NOX emissions.

Chemical industry

- The analysis of chemical industry throughout Europe followed the **Impact Pathway Approach** thanks to the EMEP database for standard and micro pollutants emissions (SOx, NOx, particulates, POPs, NMVOC, heavy metals) while the UNFCCC web database was used to identify greenhouse gas emissions coming from the chemical industry.
- Due to the sector's specificity, it was also necessary to analyse separately the burdens from energy processes and the burdens directly associated with the chemical processes in the chemical industry.
- **Specific damage factors** developed in the NEEDS project were applied for particular pollutants while the impact of greenhouse gasses were then valued thanks to the FUND model results, with distinctive valuation scenarios using different normative assumptions regarding discount rates and world equity impacts.

Chemical industry

- The **energy consumption** of the chemical sector follow similar patterns to all fossil energy based industries, generating about **€ 1.6 Billion of external costs**, excluding GHGs. These are mainly caused by the incineration of coal and heavy fuel oils, with the associated emissions of SOX, NOX, and particulate matter.
- If we only look at **chemical processes**, disregarding GHG contributions, about **€ 2.1 Billion of external costs in 2005** were produced in 2005, 60% accounting for standard air pollutants SO2, NOX and particulate matter, while heavy metals and persistent organic pollutants account for about 10% of these costs. More surprisingly, **30% of total external costs from chemical processes are associated with NH3**.
- Total external costs associated with **GHGs range between € 1 Billion and € 4 Billion**, depending on the valuation scheme used for GHGs.
- 90% of the externalities affecting climate due to the energy use of the sector are caused by carbon dioxide, while 60% of the externalities of the chemical processes are caused by N2O.



Wastes

- **Impact Pathway Approaches and Choice Experiments** were used to evaluate the environmental impact of waste management in Europe.
- Data relating to environmental burdens from waste management were identified in international databases: greenhouse gases for landfill and standard air pollutants in the case of waste incineration.
- Existing regionalised damage factors for EU countries were updated and used to estimate damages from both standard air pollutants and GHGs.
- The aggregation of costs per pollutant category and per country was performed to enable a comparison of burdens across the EU.

Wastes

- Waste management in Europe is a source of significant environmental damage. Our estimates show that the entire EU annually produces about € 2.7 billion of external costs associated with waste, which is comparable to the externalities produced by other industrial sectors, such as the entire chemical industry.
- The damage cost of **incineration ranges from about 4 to 21 €/t waste**, depending on the assumptions regarding energy recovery. The **damage cost of landfilling is around 10 to 13 €/t waste**, which is mostly due to greenhouse gases.

	Type of energy recovey				
	Heat		Electricity		
Type of disposal	Oil	Gas	Oil	Coal	Costs in €/t of wastes
Incinerator	X	-	-	-	4.5
	X	X	-	-	8.7
Landfill	X	-	-	-	10.1
	X	X	-	-	10.8
	-	-	X	X	10.9
	-	-	-	-	12.8
Incinerator^{P*}	X	X	X	X	13.1
	X	-	-	-	15.7
*partload	-	-	X	X	15.9
Incinerator	-	-	-	-	21.2