Environmental expenditures in EU industries

Time series data for the costs of environmental legislation for selected industries over time
Final report

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Preface

This report is only possible due to the commitment and work of literally 1000s of anonymous people in industries and statistical offices throughout the EU.

Due to their hard work, comprehensive statistics are available for all with an interest in the development of the economy and the environment in the EU and its member states.

They are the ones that deserve the most gratitude. Without their work, this study wouldn't have been possible.

Executive Summary

Purpose of the study

This study examines how business spending on environmental protection has changed over time. It looks to see:

- if the cumulative costs of environmental policy are increasing or decreasing;
- what are costs relative to production or value added of the sectors?
- what drives the expenditure –in response to policies on air quality, climate, waste, water, noise etc?
- is the type of expenditure changing from investment capital spending to integrated processes and operating expenditure? and
- are there differences between EU member states?

Coverage of the analysis

In this study, time series of environmental expenditures have been analysed for 6 industrial case studies: Mining and quarrying, manufacturing, refineries, chemical industries, the base metal sector and the power sector. The time series cover the period 1995 – 2012.

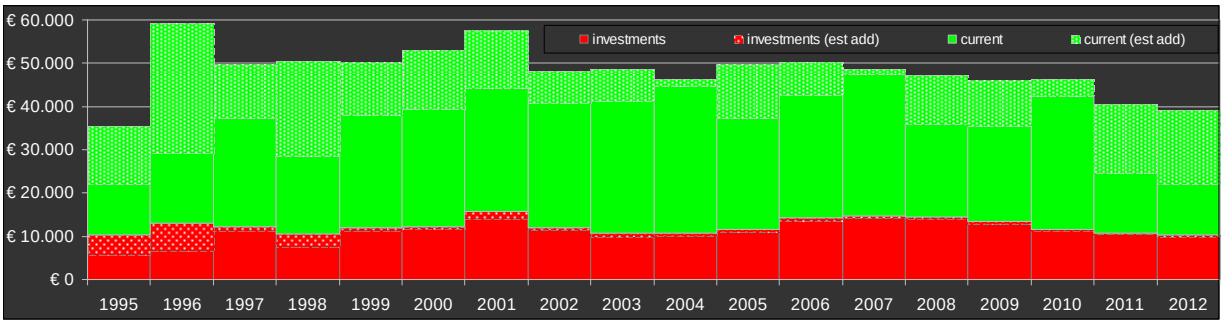
The data is collected as part of the Structural Business Statistics and the Environmental Protection Expenditures statistics by National Statistic Offices. It is then collated by Eurostat, the statistical office of the European Union which provides the European Union with statistics at European level that enable comparisons between countries and regions.

Two types of environmental expenditures are studied: investments and operational expenditures. In total, 23 member states of the EU, submit data on environmental expenditures. For environmental investments the data cover most of the years and member states, for operational environmental expenditures, the coverage of data is less abundant.

Overall figures

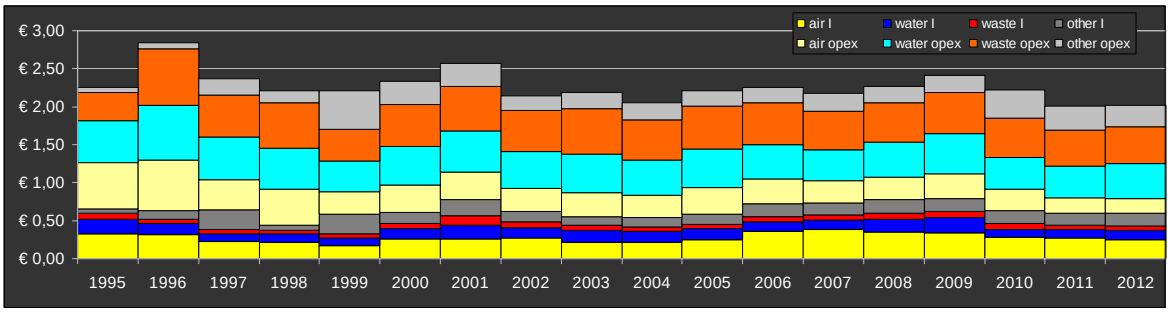
Total annual environmental expenditures in the EU of all sectors studied (mining, manufacturing and power) are estimated to have been € 60 billion in 1996 and € 40 billion in 2012 (when adjusted for inflation, price level 2012): see figure A.

Figure A. Estimated total absolute environmental expenditures of EU industries (Nace B, C, D35), in fixed prices 2012 (million Euro per year)



If total environmental expenditures, including investments and operational expenditures, are compared with value added of all sectors, the relative importance of these expenditures can be analysed: see figure B. Over the period, environmental protection expenditures accounted for **about 2% - 3% of total value added generated by these sectors**[1]. The overall analysis shows a small downward trend visible in the data presented, with "peaks" of relative expenditure in 2001 and 2009. In 2012, the figure was around 2%.

Figure B. Relative environmental expenditures (investments, operational, per environmental domain) in comparison with value added, for EU industries (Nace B, C, D35), per € 100 value added, 1995 - 2012



The overall development of relative environmental expenditures is dominated by the investments (peaks). The development of relative environmental operational expenditures of all studied sectors together shows hardly any differences during the studied period.

Sectoral differences

The analysis suggests that new and stricter environmental regulations in general do not lead to higher environmental expenditures (at the level of the EU). This is generally assumed to be because sectors become more efficient over time in responding to legislation, and so the costs of existing regulations falling over time.

However, **there are large differences between sectors and member states**. The EU averages of environmental expenditures of the different sectors, relative to the value added, are as follows:

- Manufacturing, currently, relative environmental expenditures are 1.8% of value added, ranging between 1.75% and 2.4% over the period.
- Base metal sector, currently 5.5% of value added, ranging between 3.5% and 8.5% over the period. Relative environmental expenditures are higher in the earlier and the latest years of the period;
- Power sector, currently 5.1% of value added, ranging between 2.7% and 6.1% over the period. Relative environmental expenditures start high in the early years, then drop, next increase again and during last years of the period drop again (to 2.7%);
- Chemical sector, currently 3% of value added, ranging between 2.1% and 7.3% over the period. Relative environmental expenditures start high, then drop and then increase again (to 2.8% in 2012);

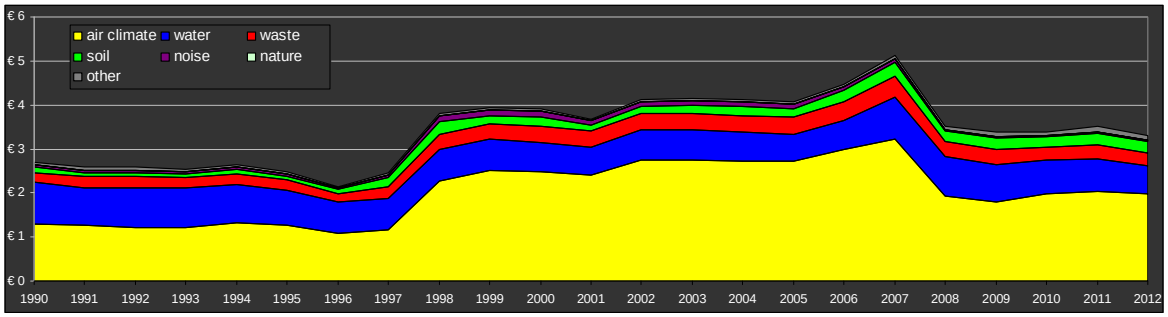
[1] Value added is the difference between the sales revenue of a sector and the total cost of components, materials, and services purchased from other firms. It is the industry's contribution to the gross domestic product (GDP) and can be understood as a measure of income from capital and labour (and so is lower than turnover).

- Mining sector, currently 2.8% of value added, ranging between 2% and 4% over the period, after 2005 between 2.7% and 3.8%;
- Refineries, currently 8% of value added, ranging between 4% and 16% over the period. Relative environmental expenditures are higher in the earlier and the latest years of the period.

Environmental investments make up between 1% and 15% of total gross investments, with large differences between sectors. For some of the sectors clear up- or downwards trends are obvious, whereas for other sectors trends are less obvious:

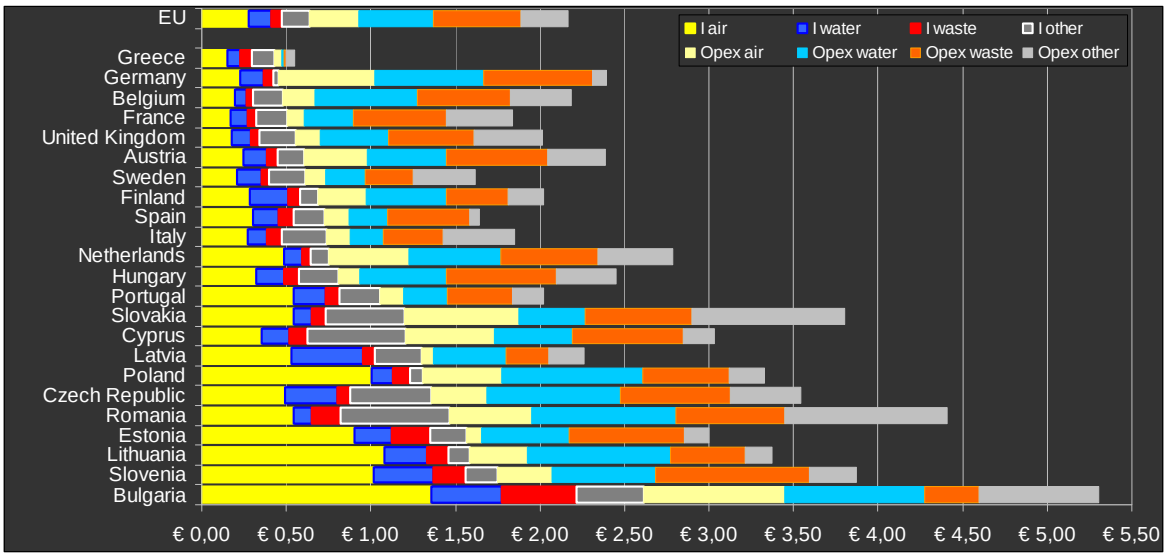
- Manufacturing industries have the lowest relative environmental investments: 3.7% to 2.6%.
- For the power sector, relative environmental investments fluctuate between 2.2% and 7%;
- for the chemical sector, between 5.2% and 2.9%;
- for the mining sector between 1.1% and 6.6%.
- Refineries have the highest relative environmental investments, between 8% and 15%, followed by the base metal sector (5.1% - 9.5% of gross investments). This leads to the peaks that can be observed in figure C, which shows costs per tonne of oil refined (this figure is for Netherlands, which has more detailed data than most other Member States, and also a large refining sector).

Figure C. Annualised environmental expenditures (capital costs and operational costs) of oil refineries (Nace C19) in the Netherlands, € per toe (price level 2012)



There are also differences between member states. In the "old" member states, the relative environmental expenditures are in general lower than in "newer" member states. This is shown in figure D.

Figure D. Average annual environmental investments (I) and current expenditures (OPEX) of the main industrial sectors (Nace B, C and D35), per € 100 value added, 1995 - 2012



In the last 5 years of the period studied, this difference between member states is narrowing in most sector.

The share of process integrated environmental investments is increasing. As a percentage of total environmental investments it increases from 0%-15% in 1995 to 40%-50% in 2012 in all sectors studied except mining and quarrying).

Conclusions

Overall, environmental protection expenditure tends to have been decreasing slightly over time for business, and now account for about 2% of value added. However, there are differences between sectors and member states. For the trends observed, some more or less general explanations can be given:

- due to the **introduction and implementation of new regulations**, peaks in environmental investments occur, this often only leads to a temporary increase in environmental expenditures;
- **in "newer" member states** environmental expenditures are often above the EU average. A possible explanation is that these member states invested in environmental measures over a relatively short period, in order to comply with EU regulations. Another plausible cause is the scale of enterprises in "newer" member states, which is in many cases smaller than in "older" member states;
- as a **result of technological progress**, relative environmental expenditures (investment and operational) have the tendency to decrease over time. In most cases this progress goes faster than the general technological progress in industry;
- **on-going technological progress** can also be illustrated by the increased share of integrated technologies. It seems that relatively high environmental costs have a positive effect on innovative solutions that subsequently decrease those costs.

Résumé

But de l'étude

Cette étude examine comment les dépenses des entreprises en matière de protection de l'environnement a changé au fil du temps. Elle cherche à montrer :

- Si les coûts cumulatifs de la politique environnementale augmentent ou diminuent;
- Quels sont les coûts relatifs à la production ou la valeur ajoutée des secteurs?
- Ce qui motive les dépenses -en réponse aux politiques sur la qualité de l'air, le climat, les déchets, l'eau, le bruit, etc.?
- Est-ce que le type de dépenses évolue de dépenses de capitaux d'investissement vers des dépenses de processus intégrés et d'exploitation; et
- Y at-il des différences entre les Etats membres de l'UE ?

La couverture de l'analyse

Dans cette étude, les séries chronologiques des dépenses environnementales ont été analysées pour 6 études de cas industriels: les industries minières, la fabrication, les raffineries, les industries chimiques, le secteur des métaux de base et le secteur de l'énergie. Les séries chronologiques couvrent la période 1995-2012.

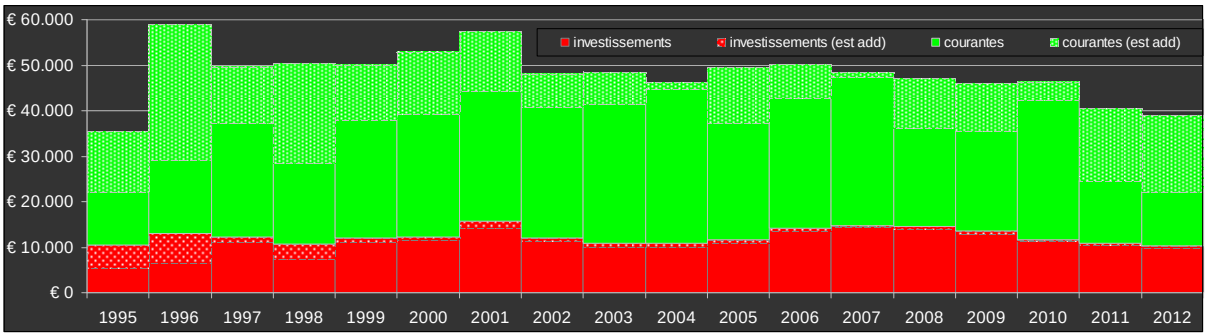
Les données sont collectées dans le cadre des statistiques structurelles sur les entreprises et des statistiques sur les dépenses de protection environnementale par les offices nationaux de statistiques. Elles sont ensuite compilées par Eurostat, l'office statistique de l'Union européenne, qui fournit à l'Union européenne des statistiques au niveau européen, ce qui permet des comparaisons entre pays et régions.

Deux types de dépenses environnementales sont étudiées: les investissements et les dépenses opérationnelles. Au total, 23 États membres de l'UE soumettent des données sur les dépenses environnementales. Pour les investissements environnementaux les données couvrent la plupart des années et des Etats membres, pour les dépenses environnementales opérationnelles, la couverture des données est moins abondante.

Les chiffres globaux

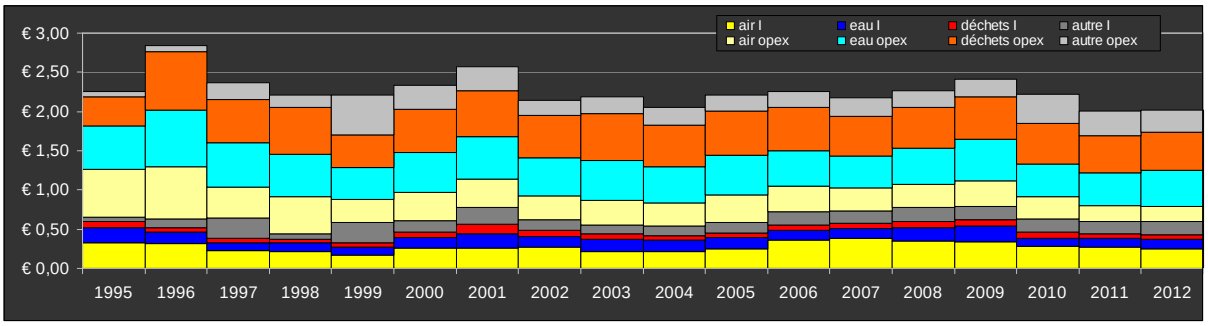
Le total des dépenses annuelles pour l'environnement dans l'UE de tous les secteurs étudiés (l'exploitation minière, la fabrication et la puissance) sont estimées avoir été de € 60 milliards en 1996 et € 40 milliards en 2012 (après ajustement pour l'inflation, le niveau des prix 2012): voir la figure A.

Figure A. Estimation du total des dépenses environnementales absolues des industries de l'UE (Nace B, C, D35), à prix fixes 2012 (mill's d'euros par an)



Si les dépenses environnementales totales, y compris les investissements et les dépenses opérationnelles, sont comparés à la valeur ajoutée de tous les secteurs, l'importance relative de ces dépenses peut être analysée: voir figure B. Au cours de la période, les dépenses de protection de l'environnement ont représenté **environ 2% - 3% de la valeur ajoutée totale générée par ces secteurs**[2]. L'analyse globale montre une petite tendance à la baisse visible dans les données présentées, avec des «pics» de dépenses relatives en 2001 et 2009. En 2012, le chiffre était d'environ 2%.

Figure B. Dépenses environnementales relatives (investissements, opérationnelles, par domaine environnemental) en comparaison avec la valeur ajoutée, pour les industries de l'Union européenne (NACE B, C, D35), pour € 100 de valeur ajoutée, 1995-2012



L'évolution globale des dépenses environnementales relatives est dominée par les investissements (pics). Le développement des dépenses opérationnelles relatives pour l'environnement de tous les secteurs étudiés montre ainsi guère de différences au cours de la période étudiée.

Les différences sectorielles

L'analyse suggère que les réglementations environnementales nouvelles et plus strictes en général ne conduisent pas à des dépenses environnementales plus élevées (au niveau de l'UE). Il doit en général en être ainsi parce que les secteurs deviennent plus efficaces au fil du temps pour répondre à la législation, et ainsi les coûts de la réglementation en vigueur baissent au fil du temps.

Cependant, **il existe de grandes différences entre les secteurs et les États membres**. Les moyennes des dépenses environnementales des différents secteurs de l'UE, relatives à la valeur ajoutée, sont les suivants:

- Fabrication, actuellement, les dépenses environnementales relatives sont de 1,8% de la valeur ajoutée, comprise entre 1,75% et 2,4% sur la période.
- Le secteur des métaux de base, actuellement de 5,5% de la valeur ajoutée, comprise entre 3,5% et 8,5% sur la période. Les dépenses environnementales relatives sont plus élevés les premières et les dernières années de la période;
- Secteur de l'énergie, actuellement 5,1% de la valeur ajoutée, comprises entre 2,7% et 6,1% sur la période. Les dépenses environnementales relatives sont élevées les premières années, puis baissent, augmentent à nouveau et rechutent au cours des dernières années de la période (à 2,7%);

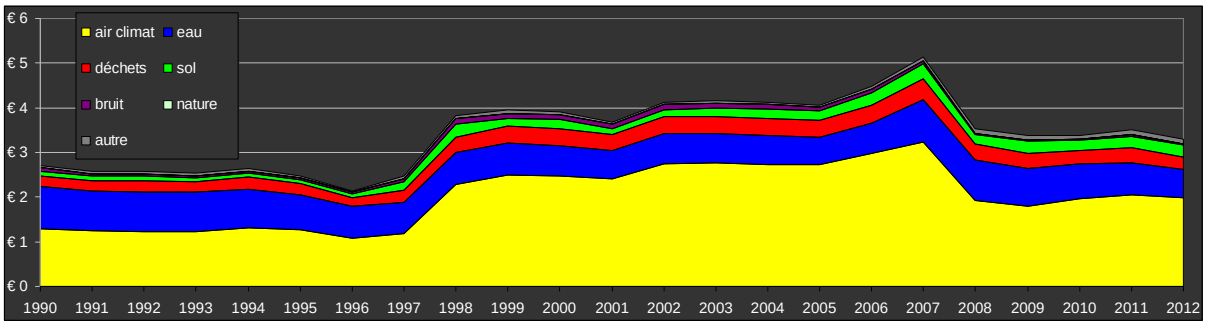
[2] La valeur ajoutée est la différence entre le chiffre d'affaires d'un secteur et le coût total des composants, matériaux et services achetés à d'autres entreprises. Elle est la contribution de l'industrie au produit intérieur brut (PIB) et peut être comprise comme une mesure du revenu du capital et du travail (et donc est plus faible que le chiffre d'affaires).

- Secteur chimique, actuellement de 3% de la valeur ajoutée, comprise entre 2,1% et 7,3% sur la période. Les dépenses environnementales relatives sont élevées au début, puis chutent et augmentent à nouveau (à 2,8% en 2012);
- Le secteur minier, actuellement de 2,8% de la valeur ajoutée, comprise entre 2% et 4% sur la période, après 2005 entre 2,7% et 3,8%;
- Raffineries, actuellement de 8% de la valeur ajoutée, comprise entre 4% et 16% sur la période. Les dépenses environnementales relatives sont plus élevées les premières et les dernières années de la période.

Les investissements environnementaux représentent entre 1% et 15% des investissements bruts totaux, avec de grandes différences entre les secteurs. Pour certains des secteurs, des tendances claires en amont ou vers le bas sont évidentes, alors que pour d'autres secteurs les tendances sont moins évidentes:

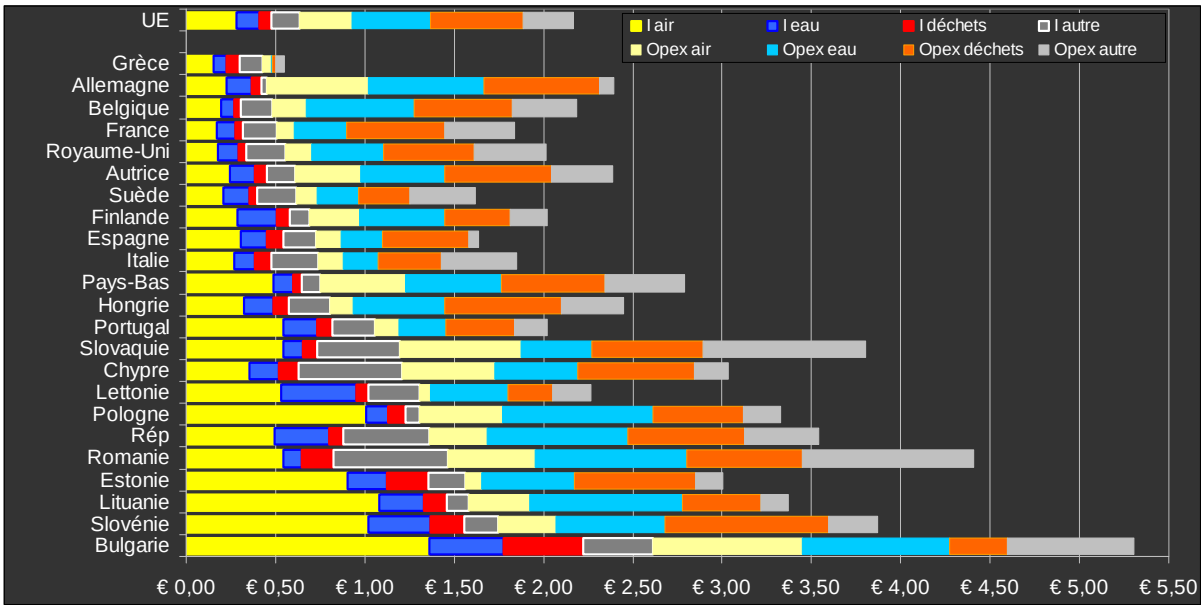
- Les industries manufacturières ont les investissements environnementaux relatifs les plus bas: 3,7% à 2,6% ;
- Pour le secteur de l'énergie, les investissements environnementaux relatifs fluctuent entre 2,2% et 7%;
- Pour le secteur de la chimie, entre 5,2% et 2,9%;
- Pour le secteur minier entre 1,1% et 6,6%.
- Les raffineries ont les investissements environnementaux relatifs les plus élevés, entre 8% et 15%, suivis par le secteur des métaux de base (5,1% - 9,5% des investissements bruts). Cela conduit à des pics qui peuvent être observés dans la figure C, ce qui montre que les coûts par tonne de pétrole raffiné (ce chiffre est pour les Pays-Bas, qui disposent de données plus détaillées que la plupart des autres États membres, et aussi un secteur de raffinage important).

Figure C. Dépenses environnementales annuelles (coûts d'investissement et coûts opérationnels) des raffineries de pétrole (Nace C19) aux Pays-Bas, € par TEP (niveau des prix 2012)



Il existe aussi des différences entre les Etats membres. Dans les États membres «anciens», les dépenses environnementales relatives sont en général inférieures à celles des «nouveaux» Etats membres. Ceci est illustré dans la figure D.

Figure D. Investissements annuels moyens pour l'environnement (I) et les dépenses courantes (OPEX) des principaux secteurs industriels (Nace B, C et D35), pour € 100 de valeur ajoutée, 1995 à 2012



Dans les 5 dernières années de la période étudiée, cette différence entre les Etats membres se réduit dans la plupart des secteurs.

La part des investissements environnementaux intégrés de traitement est en augmentation. En pourcentage du total des investissements environnementaux, il augmente de 0% à 15% en 1995 à 40% -50% en 2012 dans tous les secteurs étudiés, sauf les mines et carrières).

Conclusions

En général, les dépenses de protection de l'environnement tendent à avoir été légèrement à la baisse au fil du temps pour les entreprises, et représentent maintenant environ 2% de la valeur ajoutée. Cependant, il y a des différences entre les secteurs et les États membres. Pour les tendances observées, des explications plus ou moins générales peuvent être données:

- En raison de **l'introduction et de la mise en œuvre de nouveaux règlements**, des pics dans les investissements environnementaux se produisent, cela ne conduit souvent qu'à une augmentation temporaire des dépenses environnementales;
- **Dans les "nouveaux" Etats membres,** les dépenses environnementales sont souvent au-dessus de la moyenne de l'UE. Une explication possible est que ces Etats membres ont investi dans des mesures environnementales sur une période relativement courte, afin de se conformer aux règlements de l'UE. Une autre cause plausible est l'échelle des entreprises dans les «nouveaux» Etats membres, qui est dans de nombreux cas plus petite que dans les Etats membres «anciens»;
- Par suite **du progrès technologique**, les dépenses environnementales relatives (investissements et opérationnelles) ont tendance à diminuer avec le temps. Dans la plupart des cas, ce progrès va plus vite que le progrès technologique en général dans l'industrie;

Le **progrès technologique continue** peut également être illustré par la part accrue des technologies intégrées. Il semble que les coûts environnementaux relativement élevés ont un effet positif sur des solutions innovantes qui diminuent ensuite ces coûts.

Introduction

General

The amount of environmental regulation has increased over time and enterprises in the EU are subject to increasingly ambitious environmental demands. This may cause an upward pressure on costs of responding to environmental regulation[3]. However, empirical studies like "Sectoral Costs of Environmental Policy" (VITO, 2007) did not find this in practice.

What the 2007 study found was that environmental protection expenditures in relation to overall production costs are in general small (between 1 and 2% of production value). The study also found that annualised environmental costs vary, but do not necessarily increase over time.

Since 2007, environmental regulations have developed and stricter standards came into force. Also, more recent information is available on environmental expenditures of industries, these now cover the period 1995 – 2012/13.

For this reason, there is an interest in the development of the cost of environmental legislation for sectors of industry. Recently DG Internal Market, Industry, Entrepreneurship and SMEs (GROW) published so-called "Cumulative Cost Assessments" of the Aluminium and Steel industry, while for other sectors (chemical, refineries) such assessments are foreseen or underway. "Cumulative Cost Assessments" aim to get an overview of all costs for industrial sectors related to EU-regulation.[4]

This study analyses the most recent data on environmental expenditures of industries, and carries out several case studies for different sectors and members states. In the case studies the emphasis is on providing time series on the development of the environmental expenditures in comparison with production values (monetary and/or physical) and the underlying factors that play a role for changes in costs.

Objective and scope

This study provides an analysis of the way in which sectoral environmental costs for a selection of specific cases have changed over time. More specifically:

1. Estimate environmental costs as a percentage of production costs – and other indicators (investments, physical inputs or outputs) - over time by means of consistent time series;
2. Provide an explanation of why costs have changed over time.

The scope of this study is limited, due to the tight budget: the focus is on analysis of readily available statistics and databases on environmental expenditures and production costs/values in selected EU countries en selected industrial sectors.

[3] "Costs of environmental legislation" is also referred to as: "Environmental Protection Expenditure", "Environmental Expenditures", "Environmental Costs", "Cost of Compliance", "Environmental Protection Costs", "Costs of Environmental Management", "Pollution Abatement Costs", "Remediation Costs".

[4] "Assessment of cumulative cost impact for the steel and aluminium sectors" (2013), CEPS for DG Enterprise and Industry. This is a fairly consistent finding across industrial sectors, that resources (and their associated processing) is a dominant element of costs and often outweighs labour etc.

In line with the collection and analysis of statistical data, explanations are given on the (potential) factors that induce changes in the level and the composition of the environmental expenditures over time.

Organisation of this report

Apart from this introduction, this report contains 8 chapters.

The following chapter is on case study selection, methodology and the data used for the statistical analysis. To fully understand the ins- and outs of the analysis in the case studies, reading of the methodology chapter is recommended.

Before presenting the analysis of the 6 case studies, the next chapter gives a presentation of overall data and results, and comparisons are made between the studied sectors.

The last six chapters deal with the following sectoral case studies:

- Mining and Quarrying (Nace B)[5];
- Manufacturing (Nace C);
- Oil Refineries (Nace C19);
- Chemical Sector (Nace C20 – C22);
- Base metal sector (Nace C24);
- Power generation (Nace D35).

Each of these case studies chapters has the same base structure:

- Introduction with general sectoral information like structure of the sector, production in the EU and per member state, etc.;
- Coverage of data on environmental expenditures for member states;
- Analysis of sectoral trends (1995 – 2012) in environmental investments:
    - Estimated absolute environmental investments per environmental domain;
    - Relative environmental investments compared to gross sectoral investments per environmental domain;
    - Share of integrated environmental investments in total environmental investments;
- Analysis of sectoral trends in relative operational and investment expenditures, as share of sectoral value added generated or compared to physical in-or output of the sector, per environmental domain;
- Analysis of environmental expenditures (investments and operational) per member state, as average over the period 1995 – 2012, per environmental domain;
- Analysis of trends (1995 – 2012) in relative environmental investments per member state and per grouped member states ("EU", "old" (EU 6), "second wave" (EU 15) and "new" (EU 27), compared to sectoral value added;

[5] NACE: "Nomenclature statistique des Activités économiques dans la Communauté Européenne" refers to the industrial classification as defined in Revision 1 which is used by Eurostat.

- Environmental costs in the Netherlands. For the case studies for refineries, chemical sector, base metal and power, additionally a sectoral trend analysis is incorporated on these sectors in the Netherlands. These cover a period of 23 years (1990 – 2012). The sectoral development of specific[6] environmental costs in this period is analysed. Environmental costs include depreciation of investments and interest, and operational costs. All costs are subdivided by environmental domains.

In Annex 1, a concordance table is given for the Nace sectors of the case studies for the 3 revisions of Nace.

[6] "Specific" is used in the sense of "relative", for example "specific expenditures" is used as short for "relative environmental expenditures". This may be expenditures or costs relative to "value added" or relative to "oil refined", "steel produced" or "MWh generated".

Case-study selection, Methodology, Data

Introduction

In this chapter the case study selection will be explained. This is followed by a section in which the methodology used for the analysis presented in this study is further elaborated. This chapter concludes with an exposition of the data needed and used for this study.

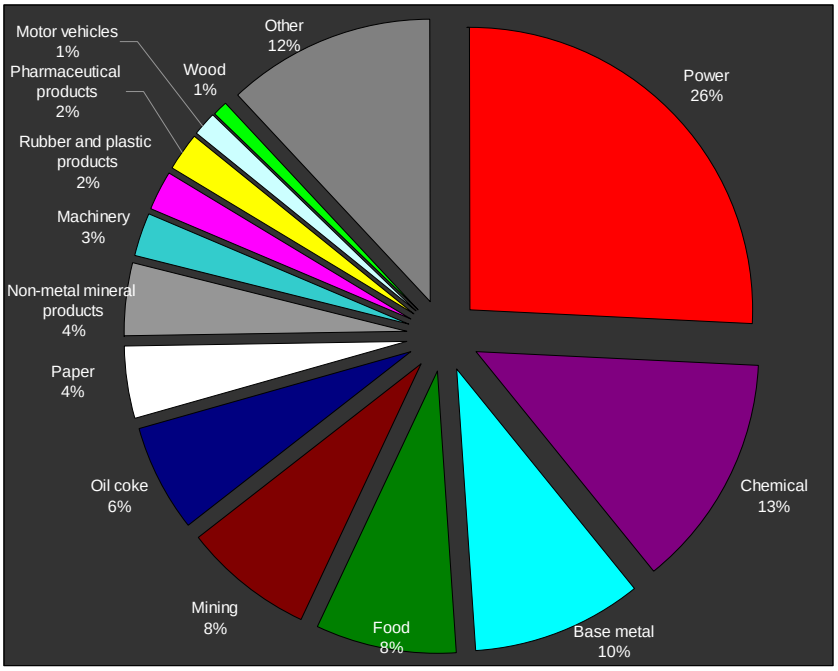
Case study selection

To select case studies from the industrial Nace[7] sectors B, C and D – mining and quarrying (Nace B), manufacturing (Nace C), electricity etc. supply (Nace D) – the following criteria are applied:

- quality of data;
- length of time for which data is available;
- variation in the sectors and in the countries in which the sectors are examined;
- a focus on sectors that are most heavily regulated.

For the 6 selected sectoral case studies, relatively complete and detailed time series are available for most of relevant the member states. Sufficient data is available (member states, years, detail of environmental expenditures, etc.) for the larger and more heavily regulated sectors. This is illustrated in figure 1.

Figure 1.1. Environmental expenditures by Nace B: Mining and Quarrying, Nace C: Manufacturing, 2-digit subdivision and Nace D: Electricity etc. supply as submitted to and recorded by Eurostat, 2008-2012[8]



[7] NACE: "Nomenclature statistique des Activités économiques dans la Communauté Européenne" refers to the industrial classification as defined in Revision 1 which is used by Eurostat.

[8] Average annual environmental investment expenditures, 2008-2012 and current expenditures 2010.

Of the six largest sectors in terms of environmental expenditures, 5 have been selected. The very diverse "food sector" is excluded. In addition, the manufacturing sector as a whole has been selected, to enable calculation of industrial totals (Nace B, C and D35) and further statistical analysis.

This leads to the following selection of case studies:

- Mining and quarrying (Nace B);
- Manufacturing (Nace C);
- Refineries (Nace C19);
- Chemical sectors (Nace C20 – Nace C22);
- Base metal sector (Nace C24);
- Power sector (Nace D35).

Methodology

Statistical Analysis

To achieve the objective of this study, statistics on environmental expenditures and financial and physical data on production of industries in the EU are collected and analysed. The main sources of information for this statistical analysis are the various statistics of Eurostat on these issues, complemented with other sources.

Data cover the period 1995 – 2012 for the following NACE sectors:

- Nace B: Mining and Quarrying;
- Nace C: Manufacturing;
    - Nace C19: Coke and refined petroleum products;
    - Nace C20-22: Chemicals and chemical products; Pharmaceuticals and pharmaceutical products; Rubber and plastic products;
    - Nace C24: Basic Metals;
- Nace D35: Electricity, gas, steam and air-conditioning supply.

Data collected and analysed for this period and these sectors is outlined in the scheme below.

Figure 1.2. Overview of data used for the statistical analysis of environmental expenditures in EU industries

Environmental expenditures:			Production values:	
Investments:		Operational expenditures:	Financial:	Physical:
End of pipe:	Integrated:			
air climate	air climate	air climate		
water	water	water	investments	crude oil
waste	waste	waste	value added	crude steel
other	other	other	production value	kWh

By comparing sectoral environmental expenditure data with corresponding financial-economic or physical data, the development of the relative importance of the environmental expenditures at sectoral level is assessed. Analysis thereof reveals

upwards or downwards trends of absolute environmental expenditures compared to investments, value added or physical production.

Data from Eurostat includes information on the kind of environmental expenditures:

- protection of air and climate, water, waste-management and other environmental domains (soil, noise, nature and landscape, etc.);
- "end-of-pipe" and "integrated" investments;
- operational expenditures: internal (personnel, energy, maintenance) and external (waste(water) services; research and development, permitting, etc.).

The specification of environmental expenditures by environmental domains, type of investments and current costs, enables the analysis of shifts in the cost-structure of environmental expenditures.

Comparison of environmental expenditures with production related values like investments, value added, production value, physical inputs or outputs, enables the analysis of upward or downward trends of relative environmental expenditures.

The data analysed comprise most member states of the EU, which makes it possible to compare the cost structures between member states and possible similarities and differences between trends in the various EU member states.

Additional specific information for the Netherlands has been included for 4 of the 6 case studies by making use of the "Environmental Costs Model". This model calculates "annualised environmental costs", which is the sum of depreciation, interest and operational costs (personnel, energy, other). The annual environmental investments are thus represented by costs of depreciation of investments and interest payments (calculated by the model in the same way the CBS calculates these costs).

This gives a more gradual representation of the annual financial-economic burden to enterprises, as it aims to allocate the investment expenditures to the years in which the investment is effective. For equipment, this period is assumed to be 10 years, for civil constructions 25 years.

Data on environmental expenditures for industries in the Netherlands are available from 1979 onwards (CBS, 2015) and incorporated in the "Environmental Cost Model". For the period 2007-2012, data have partly been estimated, making use of statistical and other sources.

The calculated annual costs, are related with sectoral indicators:

- crude oil inputs of refineries;
- value added of the chemical sector;
- crude steel production of the base metal industry;
- electricity produced by the power sector.

Potential reasons for changes

Due to the complexity of outcomes of the statistical analysis and the large differences between sectors, types of production and member states and limited resources, the analyses for the "reasons of change" is limited to the general observations. No attempt has been made to assess changes in specific cases, because this would involve at least 6 sectors, 20 member states, 2 types of investments, subdivided in 4 environmental domains, 4 types of operational expenditures, 18 years and a variety of inter-linkages between indicators that are researched.

Potential reasons for changes are:

- Introduction of (new pieces of) legislation;
- Level of enforcement;
- Regional differences;
- Differences and innovations in production technology.

Data for the statistical analysis

As already explained in the section on "Methodology", data needed for the analysis of industrial environmental expenditures includes time series covering the period 1995 – 2012 for:

- environmental expenditures of industries:
- financial-economic and physical indicators:

Ideally, for all member states of the EU, all data on environmental investments and operational expenditures, as well as data on gross investments, value added, production value and physical indicators, are available. Unfortunately, not all data needed for a complete analysis are available. For certain years and certain member states, data on environmental expenditures are not available. And for certain years member states provide only incomplete data (due to confidentiality).

History

From 1980 onwards, a few national statistical offices in the EU (i.e. Netherlands, Germany) started to collect data on environmental expenditures in the different sectors of the economy. As part of this, special questionnaires were developed to collect data on industrial environmental investments and running costs, subdivided by environmental domains (air, water, waste, other (including soil, noise, nature, etc.).

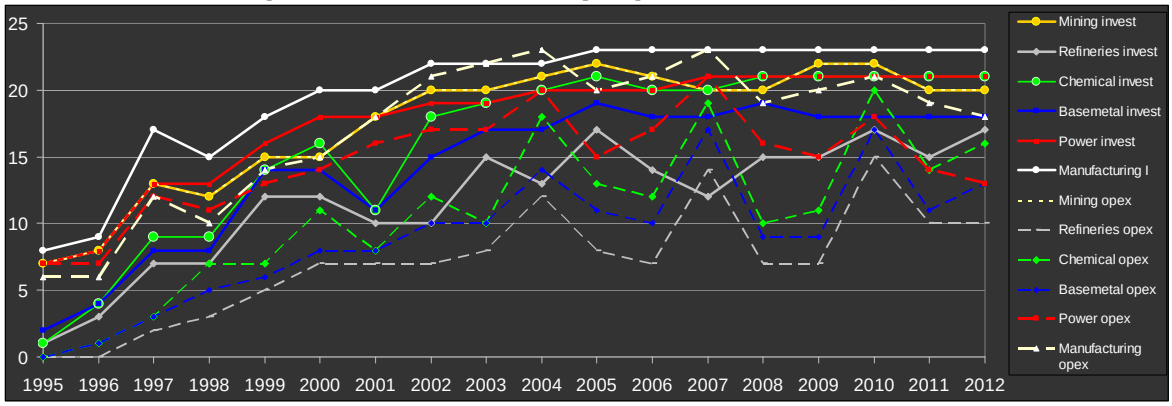
In 1992, Eurostat initiated a project on environmental expenditures in industry (Eurostat, 1994). A working group was installed in which national statistical offices and Eurostat (the European Statistical Office) co-operated to develop guidelines for data collection. This resulted in the mid-90-ties in minimal requirements on data-collection of environmental expenditures in the EU.

From 1995 onwards, national statistical offices of EU-member states started to submit data on environmental expenditures to Eurostat as part of the "Structural Business Statistics" (SBS) and the "Environmental Protection Expenditures" (EPE) statistics.

From 1997 onwards, more or less, complete time-series on environmental expenditures for the majority of EU-member states and industrial sectors are available.

Figure 3 shows the number of member states that have submitted data per sector.

Figure 1.3. Number of member states of the EU submitting data on environmental expenditures in industry – per NACE sector[9], 1995 - 2012



From 1997 onwards, the majority of EU member states have submitted data on environmental expenditures by industrial sectors (up to 23 (candidate) member states).

For environmental investments and for higher levels of sectoral aggregation of operational costs (B: Mining; C: Manufacturing; D: Power) the coverage is highest.

For operational environmental expenditures at sectoral detail (refineries, chemical, base metal), the coverage in several years is lower, as many member states only submit data once in 3 years (2004, 2007, 2010).

Environmental protection expenditures of industries

EU-wide data on environmental protection expenditures are collected and contained in the "structural business statistics" (SBS) and the "environmental protection expenditures" (EPE) statistics.

Combined, the SBS and EPE comprise in principle sufficient data for analysis of environmental expenditures in EU industries. The data contained in the SBS is subdivided in 3 different databases for the periods:

- 1995-2001: Environmental investments only, no current costs information (coverage: 20 EU-countries, on average per country data for 2.5 years of the 7 years period; 12 Nace (rev. 1.0) sectors; no specification by environmental domains);
- 2001-2007: Environmental investments and current costs information (coverage: 25 EU-countries, on average per country data for 5.3 years of the 7 years period; 38 Nace (rev. 1.1) sectors, including 3 totals for Mining and Quarrying, Manufacturing and Electricity, Gas and ; specification by environmental domains)
- 2008-2012: Environmental investments and current costs information (coverage: 25 EU-countries, on average per country data for 4,67 years of the 5 years period; 29 Nace (rev. 2.0) sectors, including 2 totals for Mining and Quarrying and Manufacturing; for investments specification by environmental domains, for current costs no specification by environmental domains).

By combining these 3 databases, one database is constructed, covering the period 1995 – 2012. This database is far from complete, as for many years and many

[9] 5 member states are excluded: Luxemburg, Denmark, Ireland, Malta and Croatia.

member states data are missing for certain years, or details (like the subdivision by environmental domains) are not published.

The environmental protection expenditure statistics (EPE)[10], recently published by Eurostat, contain comparable data as the SBS (1995-2012, main sectors selected for the case studies, investments, operational expenditures, etc.). For some member states, the EPE database contains complementary data (more years, detailed by environmental domains), in some cases data of SBS and EPE are overlapping. In the latter case, sometimes there are obvious differences between the data-sets. In these cases, the most likely numbers have been selected[11].

For the power sector, EPE statistics only present data that include also Nace E36 (water supply, etc.). The environmental expenditures of sector E36 are (very) small compared to those of sector D35 (power, etc.). Therefore, data taken from the EPE are also used as to increase data coverage considerably. This may lead to some small overestimations of environmental expenditures of the power sector.

To obtain one consistent database, covering all available data, the two data-sets (SBS and EPE) are combined in one database, which forms the basis for the statistical analysis.

Sectoral data on production, value added and investments

To enable the statistical analysis of environmental expenditures, sectoral data on production, value added and investments are added to the database for corresponding years.

The Structural Business Statistics contains (long) time-series on a variety of business indicators, including:

- production values;
- value added;
- gross investments.

As is the case with the environmental expenditures contained in SBS and EPE, many time-series on sectoral production and investments are incomplete. To enable comparison of environmental expenditures with production related indicators, data for corresponding years need to be available. Therefore, next to the Structural Business Statistics, data on production, value added and investments from the "KLEMS" databases for European countries[12] have been used, to arrive at corresponding data.

Sectoral data on physical production

For refineries, base-metal and power, the sectoral physical inputs or outputs are more or less homogenous. This enables a comparison between the sectoral environmental expenditures and the physical in- or output:

- all refineries use crude oil as inputs;
- all base-metal industries sectors in member states produce crude steel;
- all power plants produce electricity.

[10] detailed data (NACE Rev. 2) [env_ac_exp1r2] Last update: 24-04-2015
[11] "likely" in the sense that the numbers have the "best fit" in the time-series.
[12] The EU KLEMS database is constructed by an EU sponsored consortium of various institutions in Europe and abroad. Currently it covers data until 2010 for selected countries (not all EU member states) http://www.euklems.net/ can be used)

Data on oil refined in European refineries is taken from the International Energy Agency (IEA, 2015). Data is available for all relevant years and (oil refining) member states.

Data on the production of crude steel is from the World Steel Association (2015). Data is available for all relevant years and (steel producing) member states.

Data on electricity production is available from Eurostat. These data do not allow exact differentiation between electricity produced by the Nace sector D35 and other electricity producers (large CHP, industries, etc.).

Measuring environmental expenditures of industries

Data on environmental expenditures are collected by national statistical offices, which all apply their own questionnaires on environmental expenditures. In the 90-ties, Eurostat initiated the development of common practices in European countries for gathering such information, leading to a manual for data collection (Eurostat, 1994).

Quality of data depends on questions specification and understanding of questions by respondents/industries.

"End-of-pipe" investments are relative easy to measure. The measurement of "integrated investments" is more difficult.

For current costs, several types can be distinguished:

- internal operational costs of investments (personnel, energy, maintenance, etc.)[13].
- administrative costs and research;
- payments for external services like:
    - waste collection;
    - sewerage;
    - wastewater treatment;
    - research and administrative support (i.e. for permits).

For all types of expenditures, differentiations between environmental domains are included.

The way in which data are surveyed, has a large impact on the quality of the collected data. The more specific the questionnaires are, the more reliable data can be collected. On the other hand, the larger the amount of data required, the larger is the chance that respondents will submit incomplete, incorrect or estimated data.

In this study, it is assumed, that the data submitted by industries and collected by national statistical offices and Eurostat are a reliable basis for the statistical analysis. No attempt has been made to compare the data-collection procedures in the 27 EU member states.

Estimation of missing data

For some member states and some years, some but not all data needed for the statistical analysis are available. This mainly concerns the specification of

[13] Recently, the CBS in the Netherlands has decided that "The running costs of environmental investments from 2012 onwards no longer will be calculated because CBS has no meaningful and efficient method to determine reliable figures for this."

environmental expenditures by environmental domains (air, water, waste, other) or a missing total.

In order to maximise the use of available data, missing data on sectoral environmental expenditures, investments, value added is estimated. This is limited to member states for which for certain years some but not all data is available, and reasonable estimates can be made for missing data.

Estimation of data on environmental expenditures

In many cases, data on environmental expenditures or economic indicators (sectoral gross investments, value added) are incomplete. For almost all of the member states, there are breaks in the time series from 1995-2012.

Due to reasons of confidentiality data are left out of the statistics. This is especially the case for detailed data (environmental domains, specific industrial sectors) of mostly smaller member states.

Examples of incomplete data are:

- a sectoral total is given, but a subdivision by environmental domain is incomplete or lacking;
- no sectoral total is given, but for some environmental domains, numbers are available.

In both cases, it is easiest to exclude the incomplete information from the analysis. This would lead to ignoring a lot of the available information on environmental expenditures in the analysis, making it less complete/valuable.

In most cases of incomplete data, it is possible to make reliable estimates of totals or more detailed data on expenditures (environmental domains). Most commonly, some sort of interpolation can be applied to assess missing data.

If totals are known, but the subdivision is only partial (for example for only 2 of the 4 environmental domains data are available), it is often possible to estimate expenditures for the remaining domains (comparison with other years). If this is not possible, the expenditures remain unspecified under "other domains".

In case the sectoral total for a certain year and country needs to be assessed, the minimum value (sum of available data on expenditures per environmental domain(s)) can be calculated, but often also a maximum value (as total expenditures for total manufacturing are known and most of other sectoral totals as well, which sets a maximum limit). By further analysis of the environmental expenditures in the different sectors in manufacturing in the country reasonable estimates can be made for the missing sectoral total.

In case of breaks in time series (no total, no specifications for environmental domains), no attempt has been made to assess data for these "missing years".

Estimation of data on sectoral investments and value added

For some years, data on sectoral investment and value added, corresponding with the database on environmental expenditures, are not available in the SBS. Complementary data are available from the KLEMS databases (KLEMS). These data differ slightly in definition with the SBS production data.

In case neither SBS or KLEMS databases provide data for a member state, estimations have been made of sectoral investments or value added.

Overall accuracy

The overall accuracy of the analysis presented in this study depends on two factors:

- data coverage: a low data coverage will make the analysis less representative;
- estimation of missing data, as described above.

At the overall EU-level, the possible inaccuracy due to estimation of missing data is somewhere between 1% (totals) and 5% (specific per domain). The "estimation error" at EU level is (much) lower than for individual member states (10 – 30%) for several reasons:

- most of the estimated data refer to smaller member states, which only represent a small share in the EU-totals;
- sometimes estimates will be too high, sometimes too low. In general, this leads to a smaller error in the total.

As indicated earlier, low coverage forms a problem especially for data on operational environmental expenditures. This may cause a much larger bias in the time series than caused by estimation of "missing data". If for example only 30% of the EU is covered, with "low" specific costs[14], it may well be that for the missing 70% specific costs may be 2 times higher, which would lead to 70% higher specific costs as "actual" EU average for the specific costs!

Databases used for the statistical analysis

For the purpose of this project, databases for all 6 case studies and other databases are constructed from the statistical sources available, together with a few additional estimates.

These databases cover:

- an 18 years period: 1995 - 2012;
- 6 sectors: mining, manufacturing, refineries, chemical, base metal, power;
- up to 28 member states of the EU;
- per country, per year, by the environmental domains: air & climate, water, waste, other - specific figures on environmental investments – "end-of-pipe" and "integrated" - and operational expenditures. For only a few member states, all needed data are available, for most member states there are breaks in the time series;
- corresponding financial-economic data on sectoral gross investments, value added, production value and physical production indicators. All of these databases are split up in 3: one covering all data available, one with data corresponding to environmental investments and one corresponding to environmental operational expenditures.

This results in comprehensive databases, with over 50,000 figures to be used for the statistical analysis.

With the data available for analysis, numerous statistical analyses are possible of which the most obvious are presented in this report. But many additional analyses are possible, for example by comparing individual member states with the EU average or other member states, etc.

[14] "Specific" is used in the sense of "relative", for example "specific expenditures" is used as short for "relative environmental expenditures". This may be expenditures or costs relative to "value added" or relative to "oil refined", "steel produced" or "MWh generated".

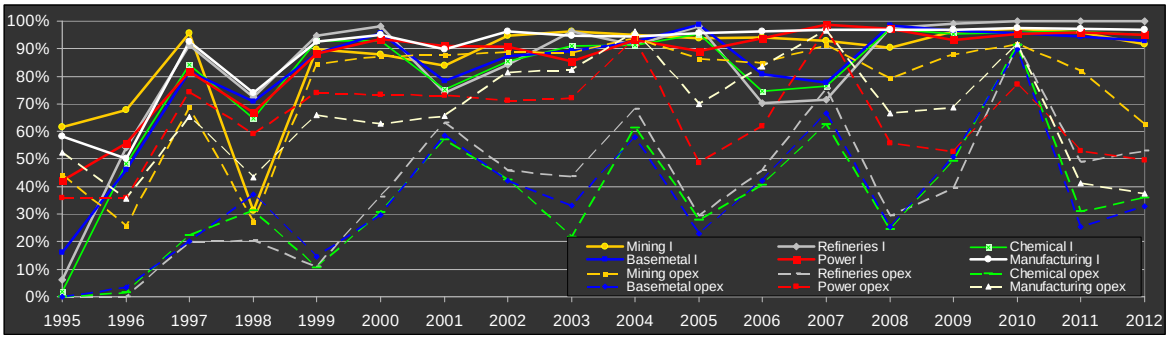
Overall results for all industrial sectors studied

Before entering into sectoral details in the next chapters, an overview is given of the overall results for the sectors analysed: mining, manufacturing, power, refineries, chemical sector and base metal.

Sectoral coverage

The coverage of data on environmental expenditures (investments and operational expenditures) is shown in the next figure.

Figure 2.1. Approximate coverage of the data on environmental expenditures on basis of value added in member states of the sectors studied, 1995 - 2012



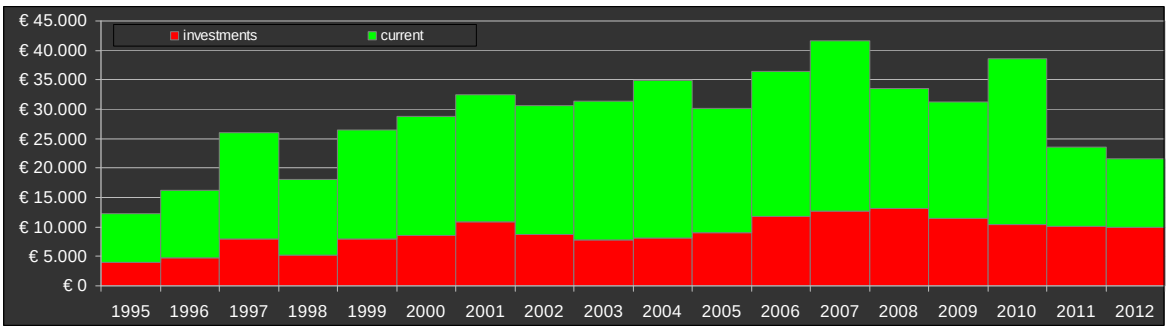
As already mentioned in the previous chapter, for environmental investments and for higher levels of sectoral aggregation of operational costs (B: Mining; C: Manufacturing; D: Power) the coverage is highest.

For operational environmental expenditures at sectoral level (refineries, chemical, base metal), the coverage in several years is as low as only 30%, as many member states only submit data once in 3 years (2004, 2007, 2010).

Total environmental expenditures in selected EU industries

Total recorded environmental expenditures in the industries studied are presented in the next figure.

Figure 2.2. Absolute environmental expenditures of EU industries (Nace B, C, D35) recorded by Eurostat, in current prices (million of Euro per year), 1995 - 2012



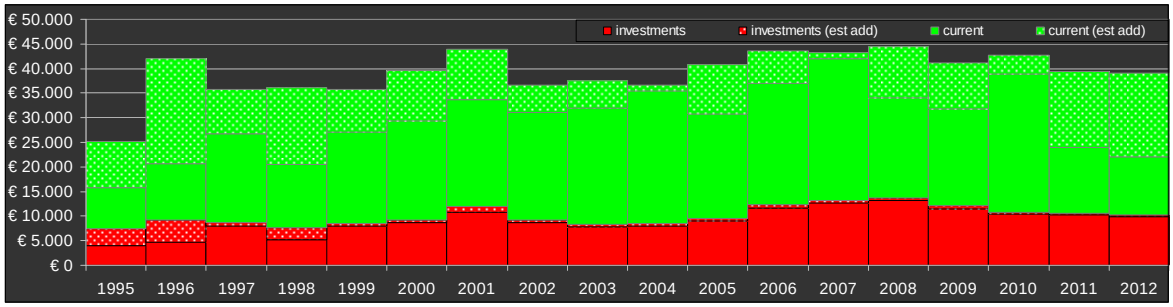
Due to incompleteness of data on current expenditures, for most years the figure gives an underestimation of expenditures. Only for a few years, 2004, 2007 and 2010,

the estimates are based on (almost) 100% coverage. This indicates that annual environmental expenditures are in the range of € 35 billion to € 45 billion.

Note that the figures are presented in prices at the time of measurement, and so are not corrected for inflation using GDP deflators. Adjusting through GDP deflators has a significant impact over such a long time period. If expenditures are € 100 in 1995 (price level 1995) they would be € 141 if measured in euros of 2012.

By complementing the recorded expenditures with estimated expenditures (by applying the coverage factors), total expenditures can be estimated. The results thereof are shown in the next figure.

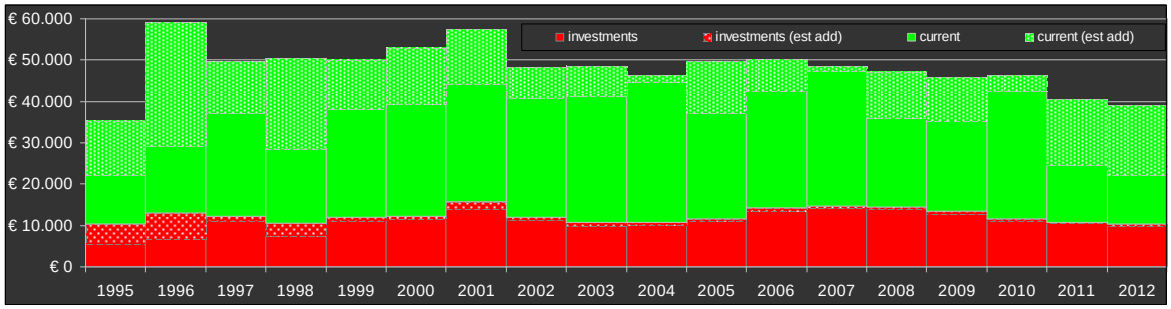
Figure 2.3. Estimated total absolute environmental expenditures of EU industries (Nace B, C, D35), in current prices (million Euro per year), 1995 - 2012



This figure confirms that for almost all years, **the environmental expenditures of industry range from € 35 billion to € 45 billion per year (before adjusting for inflation)**. In absolute terms, expenditures are broadly constant from 1996 onwards with small fluctuations.

However, if inflation is taken into consideration, and all expenditures are expressed in price level 2012, a downward trend is obvious. This is shown in the following figure.

Figure 2.4. Estimated total absolute environmental expenditures of EU industries (Nace B, C, D35), in fixed prices 2012 (million Euro per year), 1995 - 2012



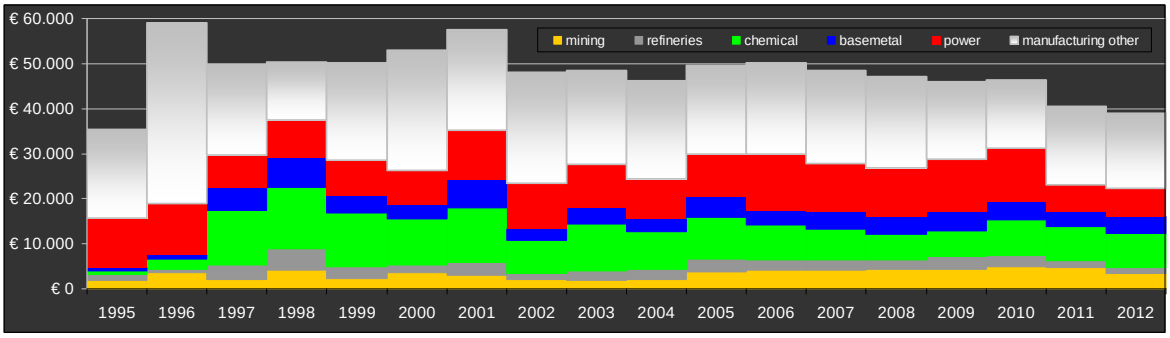
Environmental expenditures of industries range mostly from € 40 to € 60 billion per year, when adjusted for inflation, with higher values in the earlier years and lower values in later years.

Compared to the annual value added generated in the EU in the sectors NACE B: Mining, C: Manufacturing and D35: Power, which amounts about € 2,000 billion per year[15], the environmental expenditures vary between 2% and 3% of value added.

[15] Total GDP in the EU 28 is about € 13,500 billion.

The next figure represents the sectoral subdivision of the total estimated environmental expenditures in fixed prices.

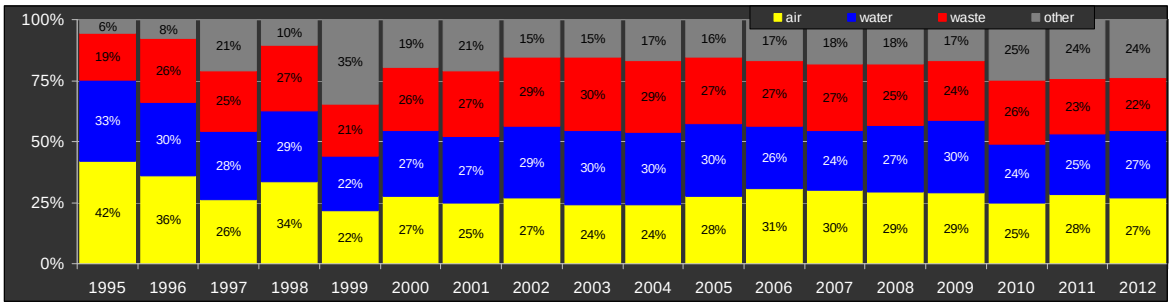
Figure 2.5. Estimated total absolute environmental expenditures of EU industries (Nace B, C, D35), per sector, in fixed prices 2012 (million of Euro per year), 1995 - 2012



The power and chemical sector have the highest environmental expenditures, followed by the base metal, mining sector and refineries. On average, over 50% of total environmental expenditures in the NACE sectors B, C and D, is covered by these 5 specific – case study - sectors.

The purpose of the expenditures, (protection of) air and climate change, water, waste management and other expenditures (soil, noise, nature, research, administration), has slowly changed during the period 1995 – 2012. Whereas the expenditures are dominated by "air" and "water" in the early years, after 2000 these domains count for a little more than 50%. Waste management and "others" form the rest of the environmental expenditures. There is no clear difference between the expenditures for the three main domains. In some years "air" shows highest expenditures, in other years "water" or "waste".

Figure 2.6. Subdivision by environmental domains of estimated environmental expenditures of EU industries (Nace B, C, D35), 1995 – 2012



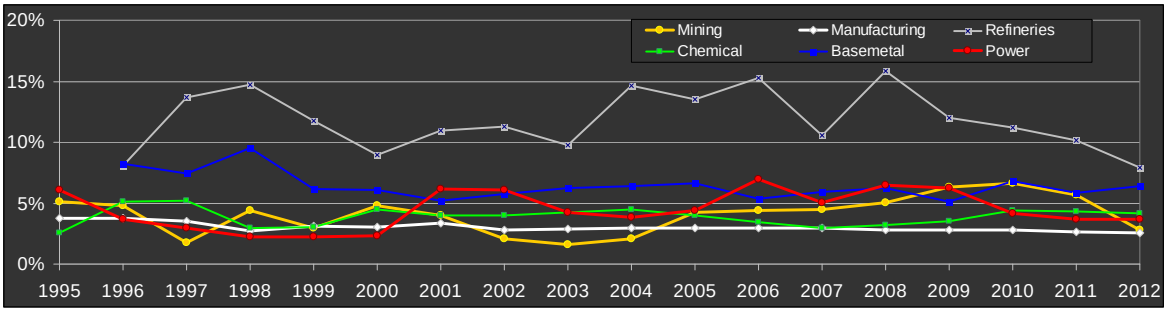
As data coverage of operational environmental expenditures is low for most of the years (excluding for example some of the largest member states), any trend observed in the above figure, may not be representing the actual developments.

Environmental investments

Environmental investments constitute approximately 1/3 of total environmental expenditures. Data coverage for investments is high (>90% in most years for most sectors), enabling a credible trend analysis of sectoral environmental investments.

In figure 2.7, sectoral environmental investments are compared with total sectoral investments.

Figure 2.7. Relative environmental investment expenditures of EU industries (Nace B, C, D35), as share of total sectoral investments, 1995 - 2012



The highest relative environmental investments are observed for the oil-refining sector, ranging from 7 to 17 % of total investments. Other sectors (except base metal) peak at about 7%. The lowest relative environmental investments (2%) are observed for mining sector.

It is not possible to distinguish a general trend of the environmental investments for all sectors together.

Environmental investments in the power sector fluctuate between 2 and 7%. A potentially expected increase of environmental investments due to investments in "renewable energy" is not visible the reported data.

For the chemical sector environmental investments fluctuate (consistently) between 3-5% of sectoral investments.

For the oil-refining sector the environmental investments (7-17% of total sectoral investments) decrease during the last 5 years of the whole period. It is not certain if this is temporary or prolonged.

After relative high environmental investments in the early years for the base metal sector, after 1998 these investments are stable at between 5-7% of sectoral investments.

For the mining sector, environmental investments fluctuate between 2-7% of total sectoral investments. In the period 2006-2011, relative environmental investments are above average, but in 2012 they drop back to average level.

Environmental investments for the manufacturing industries (in total) range from 2.5% to 4%. Compared to the other case study sectors, these are on average the lowest (with a few exemptions). This shows, that the selected sectors for the case studies have above average environmental investment expenditures.

More details on the sectoral environmental investments can be found in the separate chapters which cover the 6 case studies.

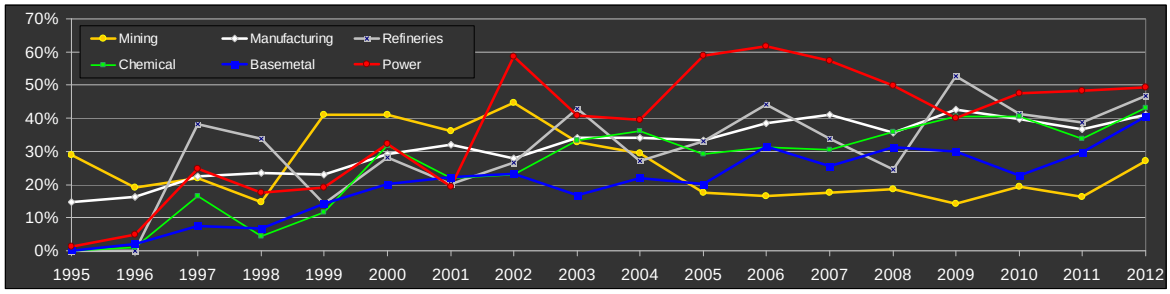
A special feature of the Eurostat statistics on industrial environmental investments is the separate recording of the type of investments:

- "End of pipe" or investment in equipment and plant for pollution control;
- "Integrated" or investment in equipment and plant linked to cleaner technology.

"End of pipe" solutions were the primary answer to abate the pollution of the environment by industries in the 60-ties and 70-ties. Gradually, process integrated solutions, pollution prevention and cleaner technologies have become more common as the result of on-going innovations in production technology.

The following graph shows the relative importance of "integrated environmental investments" in the total.

Figure 2.8. Share of integrated environmental investments in total environmental investment expenditures of the sectors studied, 1995 - 2012



For most sectors an upward trend is observed. From 0% to 15% in 1995 to between 40% and 50% in 2012. This is most obvious for the manufacturing industries in total (Nace C), base metal (Nace C24) and chemical sectors (Nace C20- C22).

For the power sector (Nace D35) and oil-refineries (Nace C19), the trend is also upwards, but more irregular.

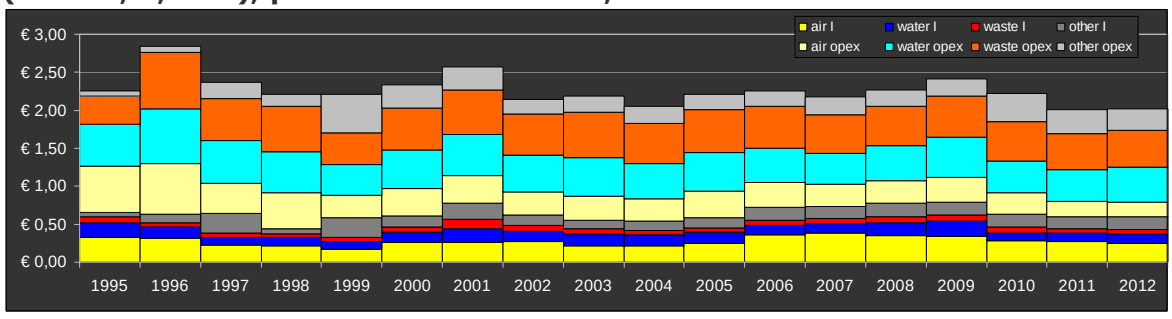
The mining and quarrying sector (Nace B) is the only exemption. No clear upward trend is visible.

Environmental expenditures relative to value added

If total environmental expenditures, including investments and operational expenditures, are compared with value added of all sectors, the relative importance and eventual trends in the development of these expenditures can be analysed.

In figure 2.9, this is done for all sectors included in this study.

Figure 2.9. Relative environmental expenditures (investments, operational, per environmental domain) in comparison with value added, for EU industries (Nace B, C, D35), per € 100 value added, 1995 - 2012



The relative environmental expenditures range from € 2 and € 2.5 per € 100 value added, with one exception (1996). There is a small downward trend visible in the data presented, with "peaks" of relative expenditure in 2001 and 2009.

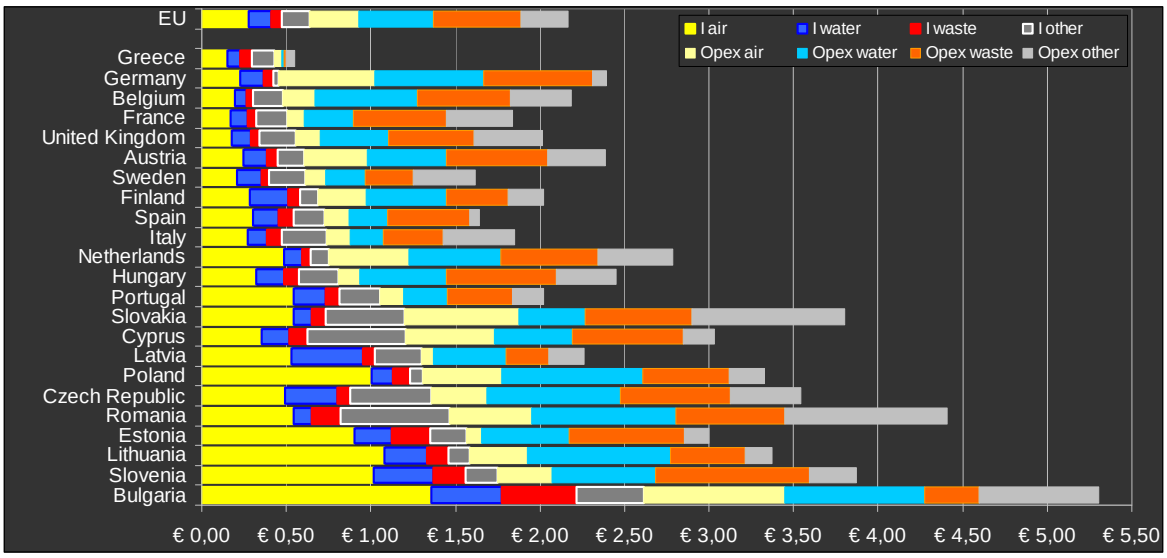
The overall development of relative environmental expenditures is dominated by the investments (peaks). The development of relative environmental operational expenditures of all studied sectors together shows hardly any differences during the studied period.

Further sectoral details of this analysis are given in the case study chapters.

Environmental expenditures of industries per member state

Differences between the member states of the EU are apparent, if the environmental expenditures of industries are differentiated by member state. This is shown in figure 2.10.

Figure 2.10. Average annual environmental investments (I) and current expenditures (OPEX) of the main industrial sectors (Nace B, C and D35), per € 100 value added, 1995 - 2012



In this figure, member states are sorted by the level of environmental investments (ranging from € 0.43 to € 2.61, EU-average € 0.64).

Operational environmental expenditures are relative higher in the majority of the member states. This leads to total environmental expenditures of between € 0.55 and € 5.30 per € 100 Value added, with an EU average of € 2.17.

In "older" member states the relative environmental investments are below average, in "newer" member states higher. For operational expenditures, differences between "old" and "new" are still present, but less obvious. For example Germany and the Netherlands have relative high operational expenditures, Portugal and Latvia relative low.

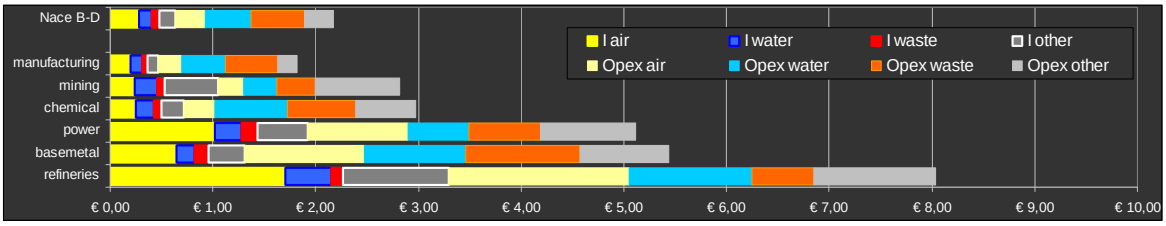
More sectoral details are given in the case study chapters.

Sectoral environmental expenditures per domain

Due to large variations in technology and the raw materials used in production processes, the environmental stress caused by the various sectors differs from sector to sector. Sectors with production processes with relatively large emissions have to take more measures to abate or prevent pollution than less polluting sectors, leading to higher environmental expenditures.

In figure 2.11 the sectoral environmental expenditures profiles for the 6 sectoral case studies are presented.

Figure 2.11. Average relative environmental expenditures – investments and operational - per € 100 Value Added of 6 industrial sectors, 1995 – 2012



Manufacturing as a whole has the lowest relative environmental expenditures: about € 0.50 investments and € 1.30 operational costs per € 100 value added. Refining crude oil leads to highest environmental expenditures of € 8.00 per € 100 value added, followed by the base metal sector (€ 5.40), the power sector (€ 5.10), chemical industries (€ 3.00) and the mining sector (€ 2.80).

The average environmental expenditures for all sectors (Nace B, C and D35) are slightly higher than € 2 per € 100 value added.

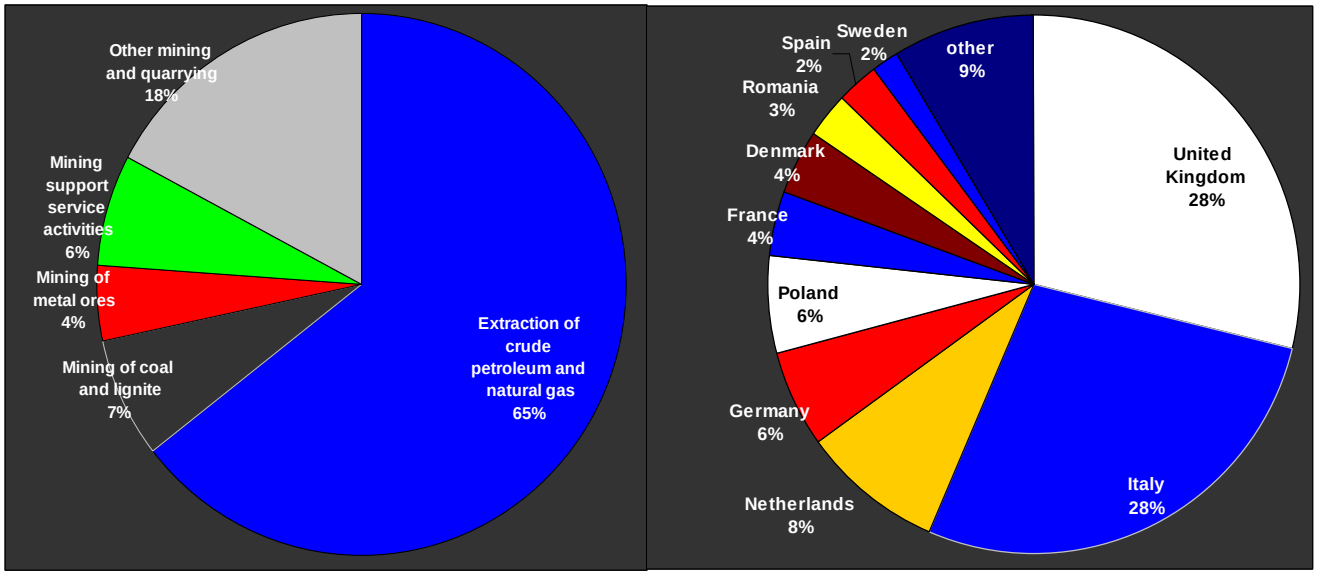
Mining and Quarrying

Introduction

The Mining and Quarrying sector (Nace B) makes up some 4% of total value added of the industries studied (Nace B, C, D35). Since 2000, the average value added generated by this sector is about € 90 billion per year.

More than two-thirds of the production generated by this sector is linked with oil, gas and coal production. 5 member states (UK, Italy, Netherlands, Germany and Poland) are responsible for over 75% of production in this sector, as is shown in the following figure.

Figure 3.1. Production values for Nace B: Mining and Quarrying sector in the EU, subdivision by activities and by member states (2005 – 2013)



Some 15% of production in the mining and quarrying sector is linked with building materials (sand, gravel, cement additives, limestone, rock & stones, pebbles, clay, etc.). Mining and processing of metal ores form a relative small part of total production (4%).

Mainly due to activities of the oil and gas industry, the United Kingdom, Italy and the Netherlands make up for almost 2/3 of total production value in this sector.

The following figure shows the structure of the mining and quarrying sector in the various member states.

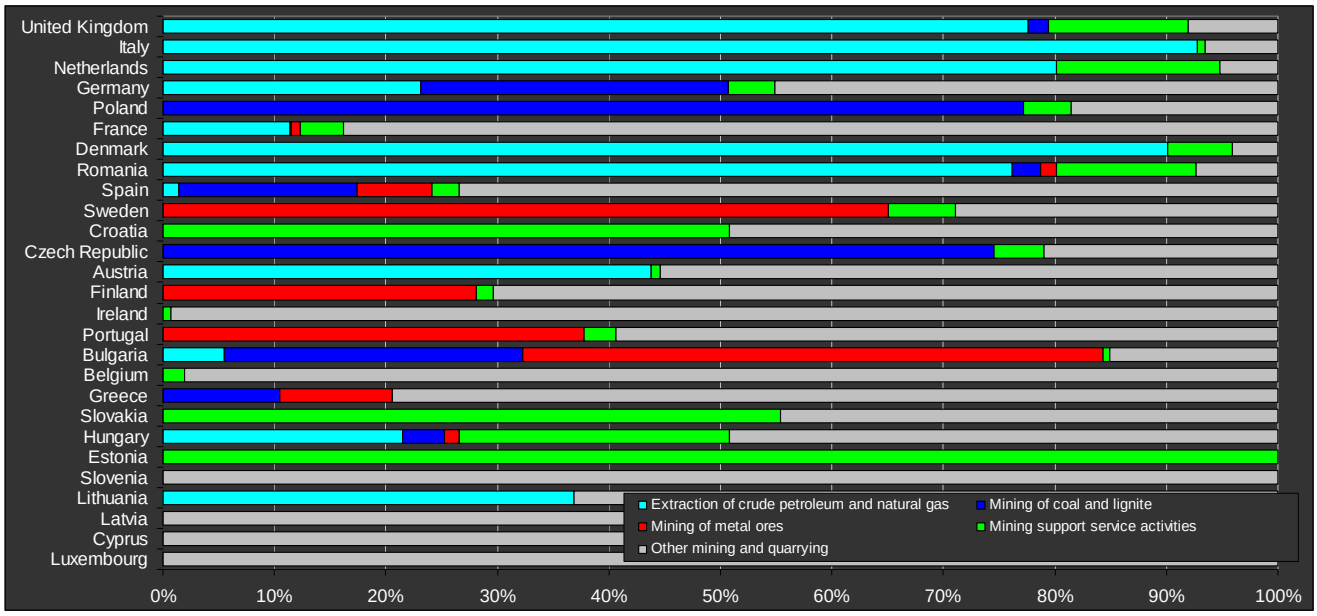
Apart from the United Kingdom, Italy and the Netherlands, oil- and gas extraction also dominate the mining and quarrying sector in Denmark and Romania.

In Germany, Poland and the Czech Republic, coal and lignite mining are important.

In a few smaller member states - Sweden, Finland, Portugal and Bulgaria - mining of metal ores plays a significant role.

In the other countries, the structure of the sector varies.

Figure 3.2. Subdivision of production in the Mining and Quarrying sector in member states (2005 – 2013)

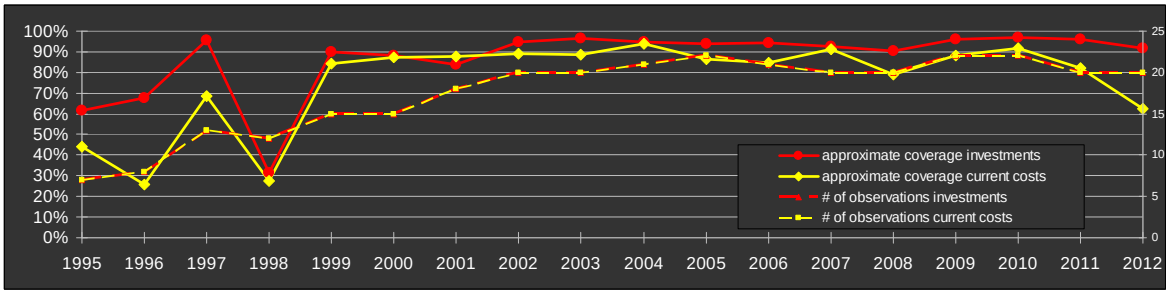


It can be concluded, that the production value of the mining sector in the EU is dominated by oil and gas extraction, and that there is a large variation of the sectoral structure between member states.

Data coverage

For the mining and quarrying sector, data coverage is relative highest of all case studies, as is shown in figure 3.3.

Figure 3.3. Approximate coverage of the data on environmental expenditures of the mining and quarrying sector in the EU, on basis of value added in member states of the sectors studied and number of member states submitting data, 1995 - 2012



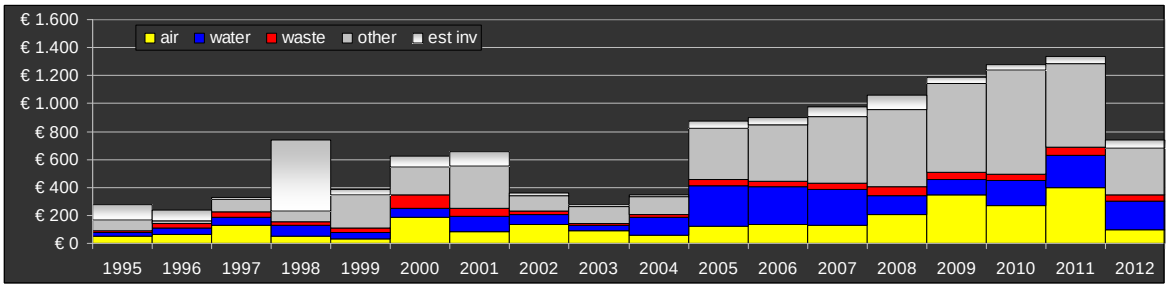
From 1999 to 2011, data coverage of environmental investments as well as operational environmental expenditures is 80% or higher.

Environmental investments of the mining and quarrying sector

The total absolute environmental investments of the mining sector subdivided by environmental domains are represented in the next figure, together with an estimation of investments for the non-responding member states. The environmental investments

of the non responding countries have been assessed by taking into account the approximate coverage of environmental investments in the statistical sample. This leads to somewhat higher total absolute investments, which peak in 2011, with € 1.3 billion.

Figure 3.4. Observed and additional estimated absolute annual environmental investments of the mining and quarrying sector (Nace B) in the EU per environmental domain, in € million per year (current price level), 1995 - 2012

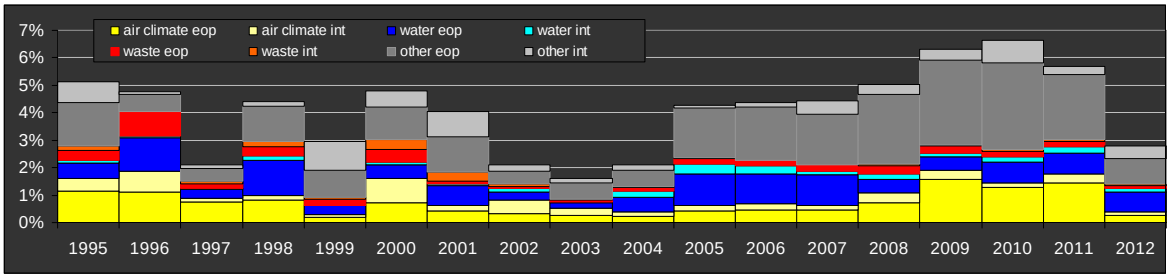


In absolute terms, investments are substantially higher from 2005 onwards (except 2012), than for years before 2005.

Environmental investments in the domain "other" (nature, soil, noise) dominate in most years. From 2004 onwards, investments for "water" become important, also investments for "air". Investments for "waste" are relative small.

Expressed as fraction of the total sectoral investments in the mining sector, also shows higher investments in the period 2005 – 2011. This is shown in figure 3.5.

Figure 3.5. Relative environmental investments as fraction of total investments in the mining and quarrying sector (Nace B), 1995 -2012

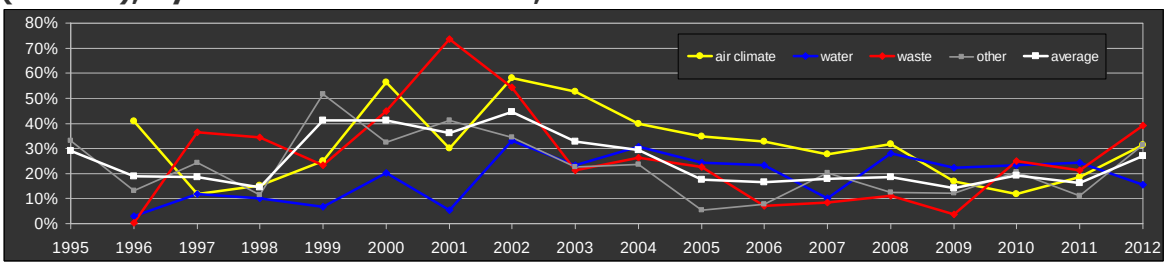


Relative environmental investments range from 1.5% to 6.5% of total investments of the mining sector. Whereas absolute environmental investments are significant lower in the years before 2005, for relative environmental investments the picture is more diverse: between 2% and 5% of total sectoral investments.

Summarised the development of environmental investments shows fluctuations in the period 1995 – 2004 (2% - 5%), from 2005 until 2011 an increasing trend, and in 2012 a sudden drop.

In the next figure, the share of "integrated" investment in equipment and plant linked to cleaner technology in total environmental investments of the mining sector are presented.

Figure 3.6. Share of integrated environmental investments in total environmental investment expenditures of the mining and quarrying sector (Nace B), by environmental domain, 1995 - 2012



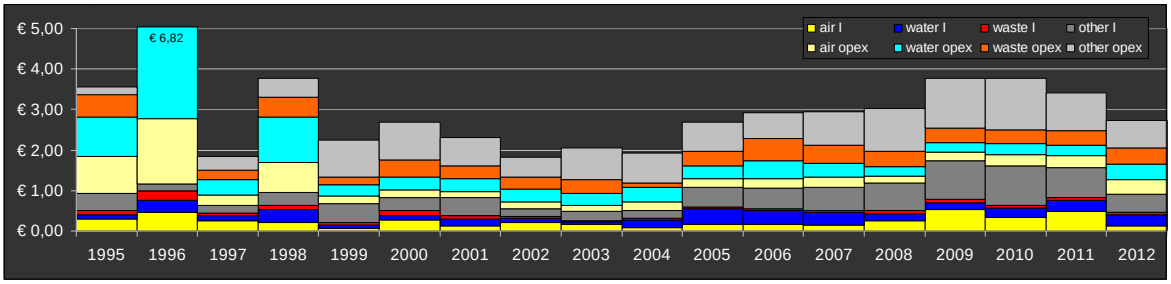
Unlike most other sectors, integrated environmental investments in the mining sector do not show an upward trend during the period 1995 – 2012. Integrated environmental investments peak in the years between 1999 and 2003 (air, waste, average). After 2002, a downward trend can be observed.

Environmental expenditures of the mining and quarrying sector

If total environmental expenditures, including investments and operational expenditures, are compared with value added of the mining sector, the relative importance and eventual trends in the development of these expenditures, can be analysed.

In figure 3.7, this is done for the mining sector.

Figure 3.7. Relative environmental expenditures (investment and operational) of the mining and quarrying sector (Nace B), per € 100 value added, 1995 - 2012



If the years for which little data (especially on operational expenditures) are excluded (1995, 1996 and 1998), a gradual development of the environmental expenditures of the mining sector can be observed:

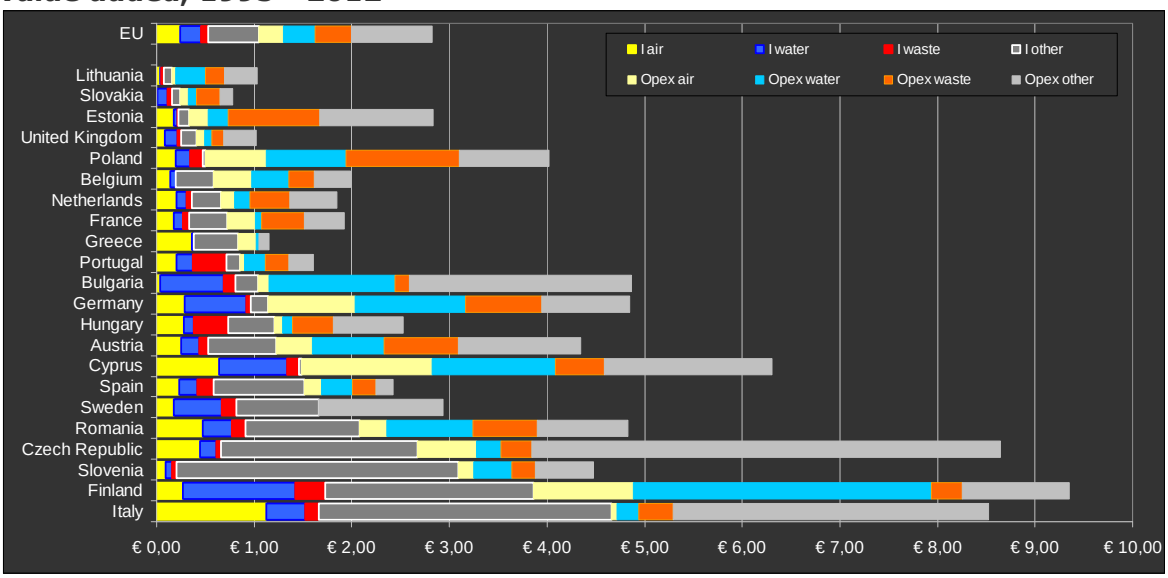
- 1997 – 2004: relative low expenditures of between a little less than € 2 per € 100 value added to € 2.7 (peak in 2000);
- 2005 – 2012: relative higher expenditures of between € 2.7 and € 3.8 (peak in 2009 and 2010) per € 100 sectoral value added.

The fluctuation in the development of environmental expenditures of the mining sector is mainly caused by fluctuations of the relative investments. In years with high environmental expenditures, environmental investments are also peaking. Less fluctuation is observed for the operational environmental expenditures.

Environmental expenditures in the mining and quarrying sector per member state

Figure 3.8 shows that the differences between observed environmental expenditures for the mining sector in the member states of the EU are large. Average expenditures are € 2.8 per € 100 value added, with investments making up € 1 thereof. But in some member states expenditures are as low as € 1 and even less (Slovakia, United Kingdom), whereas in other member states they are over € 4 (Germany) to € 8 (Finland, Italy, Czech Republic) per € 100 value added of the mining sector in these countries.

Figure 3.8. Average annual environmental investments (I) and current expenditures (OPEX) of the mining and quarrying sector (Nace B), per € 100 value added, 1995 - 2012

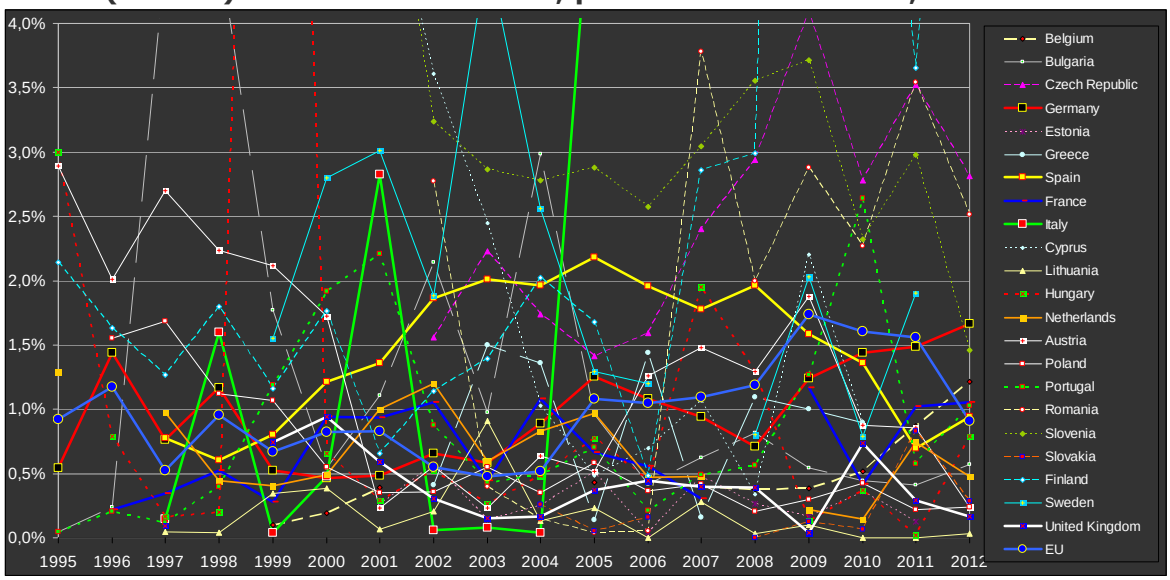


These large differences can be caused by a mixture of causes:

- specific structure of the mining and quarrying sector in the different member states;
- differences in enforcement in environmental law/regulations;
- regional environmental circumstances;
- efficiency and income generated in the sector compared to output, etc.

Figure 3.9 gives detailed information on the environmental investment expenditures in the mining sector in different member states. It shows that the development thereof is very irregular, between member states but also in consecutive years for the same member states. Years or periods with high levels of environmental investments are followed by years with lower investments. No clear general trend(s) can be observed.

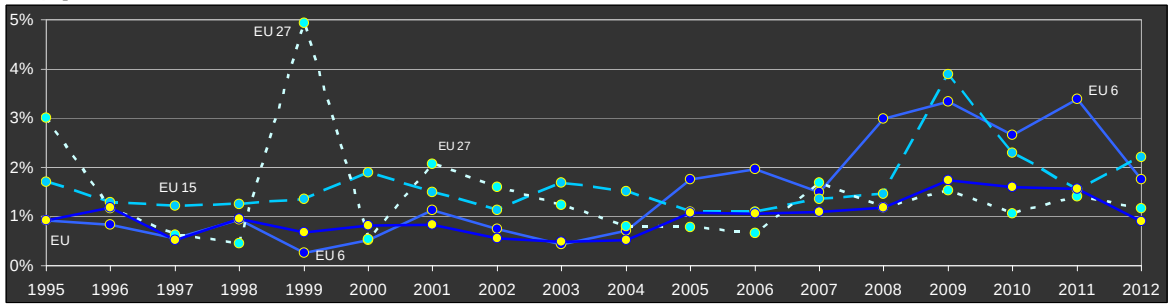
Figure 3.9. Relative environmental investments of the mining and quarrying sector (Nace B) in EU member states, per € 100 value added, 1995 - 2012



To assess if any regional trends can be observed, the EU member states are grouped in three groups:

- EU 6: Germany, France, Italy, Netherlands, Belgium;
- EU 15: United Kingdom, Spain, Portugal, Greece, Austria, Sweden, Finland;
- EU 27: Poland, Hungary, Czech Republic, Slovakia, Slovenia, Estonia, Latvia, Lithuania, Romania, Bulgaria.

Figure 3.10. Relative environmental investments in the mining sector in the EU, per € 100 value added, 1995 - 2012



Environmental investments on average range mostly from 0% to 2% of value added. There are a few exemptions:

- EU 27 (newest member states) peak in 1999;
- EU 15 (2nd wave of member states) peak in 2009;
- EU 6 (old member states) peak from 2008 till 2011.

For the mining and quarrying sector, there are no clear differences in regional trends.

Manufacturing

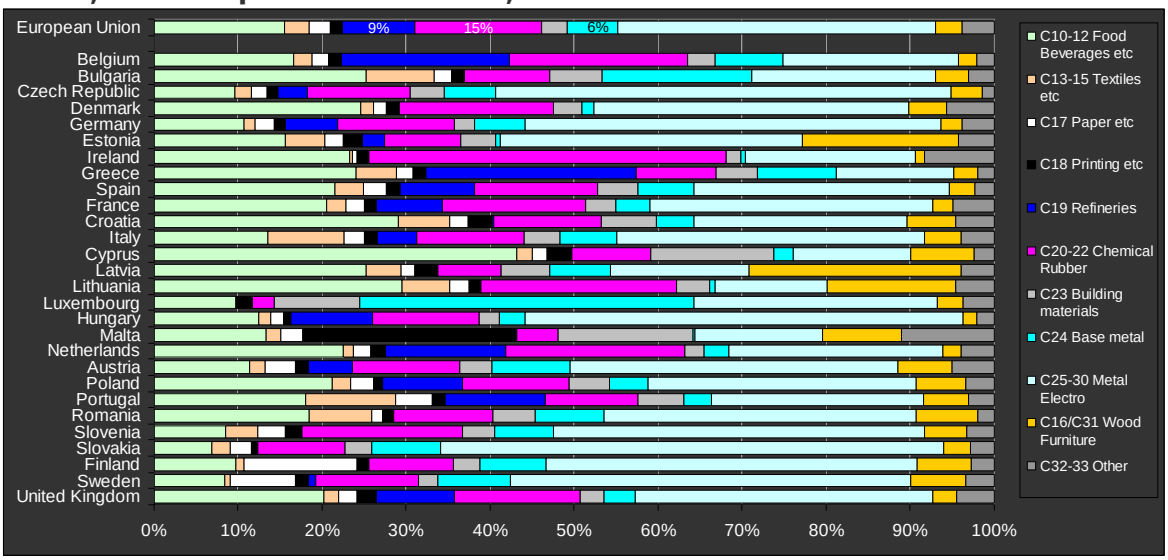
Introduction

The manufacturing industries (Nace C) are an important pillar of the economy of the European Union member states. These industries provide food, clothes, shoes, paper, oil products, plastics, cars, computers, building materials, etc. for the inhabitants of the EU member states and beyond. The annual value added generated (since 2000) by all manufacturing industries in the EU is more than € 1,500 billion.

In this chapter the environmental expenditures of the manufacturing industries in total are analysed. Attention will be paid to the development of environmental investments, the share of integrated investments, total environmental expenditures, relative environmental expenditures in member states for the environmental domains air & climate, water, waste and other.

The sectoral structure of the manufacturing industries in the 28 member states of the European Union varies, as shown in next figure.

Figure 4.1. Sectoral structure of the manufacturing industry in EU member states, sectoral production values, 2005 – 2013



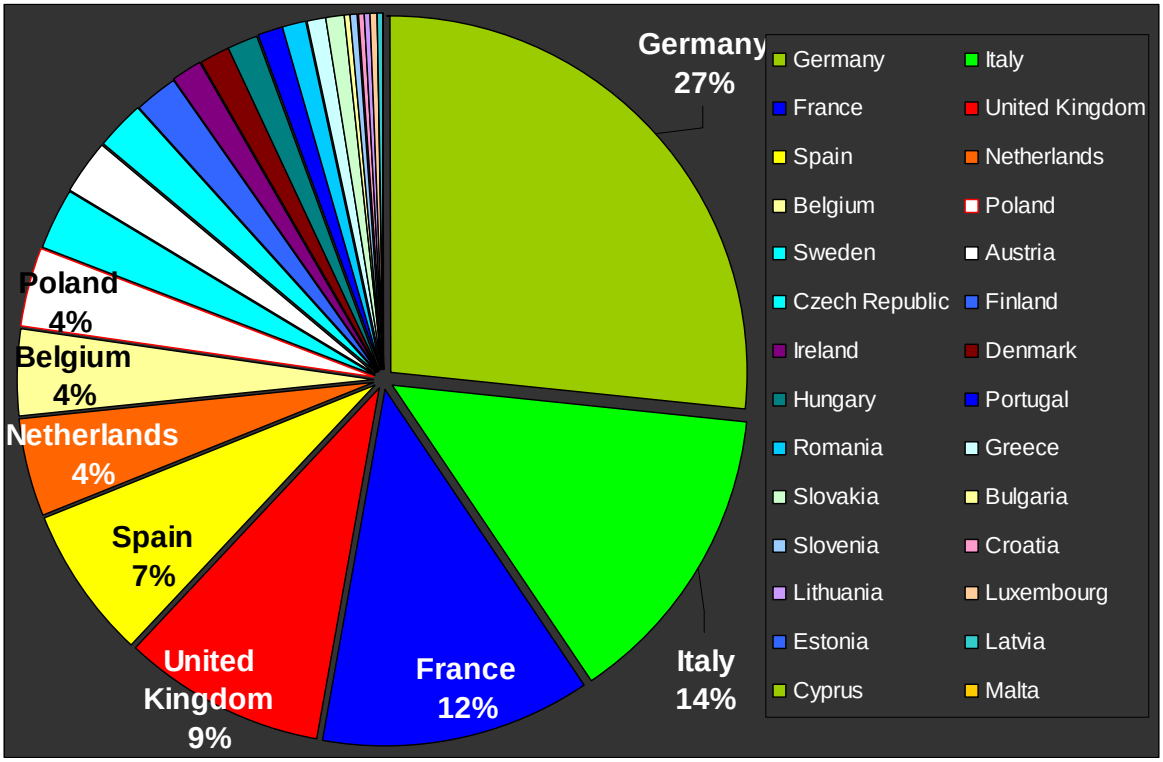
The largest industrial sectors are:

- C25-30, Metal-Electronic Manufacturing (includes machines, computers, cars, etc.),
- C10-12, Food, Beverages, etc.,
- C20-22, Chemical (products), rubber, plastics, etc.,
- C19: Oil refineries,
- C24, Basic metal industry.

The latter 3 sectors are selected for the case studies within C: Manufacturing. These 3 sectors represent 30% of the production value of the manufacturing industries and on average 43% of environmental expenditures.

Figure 4.2 shows that the >75% of the manufacturing industry is situated in 7 member states as shown in the following figure.

Figure 4.2. Production values of the manufacturing industries (Nace C) in member states of the European Union, Average 2005-2013

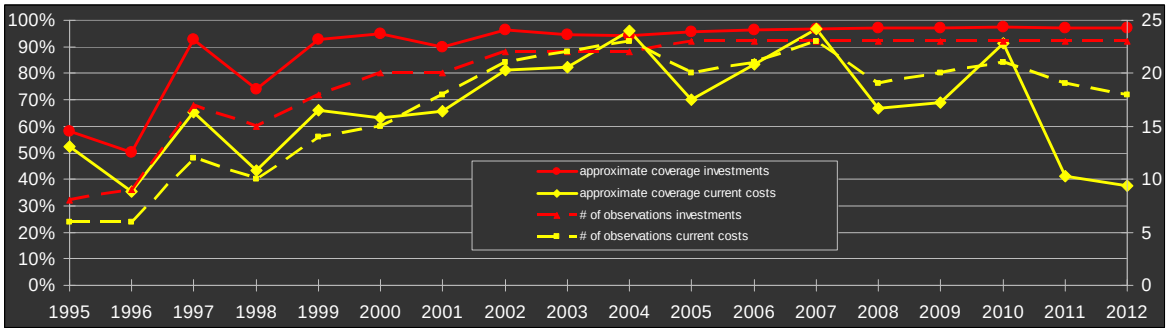


Data coverage

For the manufacturing industries, data coverage for environmental investments is high, with only 3 years with coverage of less than 90%. From 1999 onwards the coverage of investments is over 90%.

As with the other case studies the coverage of operational expenditures is lower, with only three years (2004, 2007 and 2010) with coverage of over 90%, as is shown in figure 4.3.

Figure 4.3. Approximate coverage of the data on environmental expenditures of the manufacturing sector in total (Nace C) in the EU, on basis of value added in member states and number of member states submitting data, 1995 - 2012

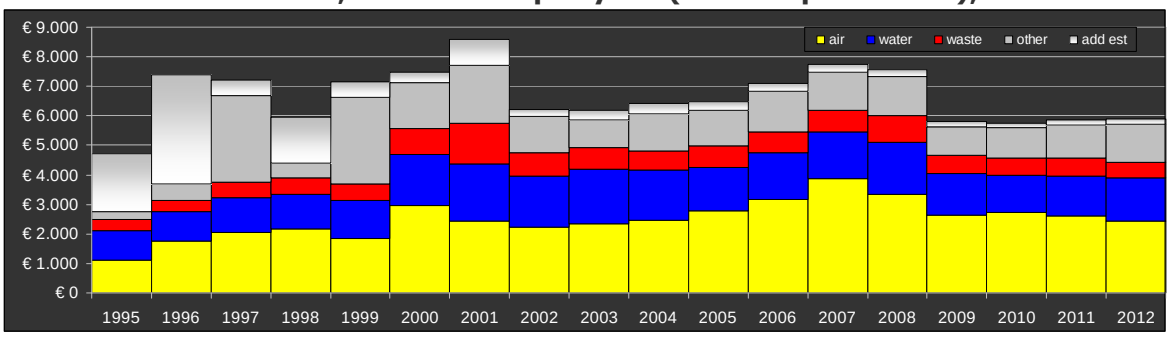


For other years coverage of operational expenditures fluctuates from under 40% to about 80%.

Environmental investments of the manufacturing industries (Nace C)

As figure 4.4 shows, environmental investments of the manufacturing industries in total range between € 6 and € 8.5 billion per year.

Figure 4.4. Observed and additional estimated absolute annual environmental investments of the manufacturing industries (Nace C) in the EU per environmental domain, in € million per year (current price level), 1995 - 2012

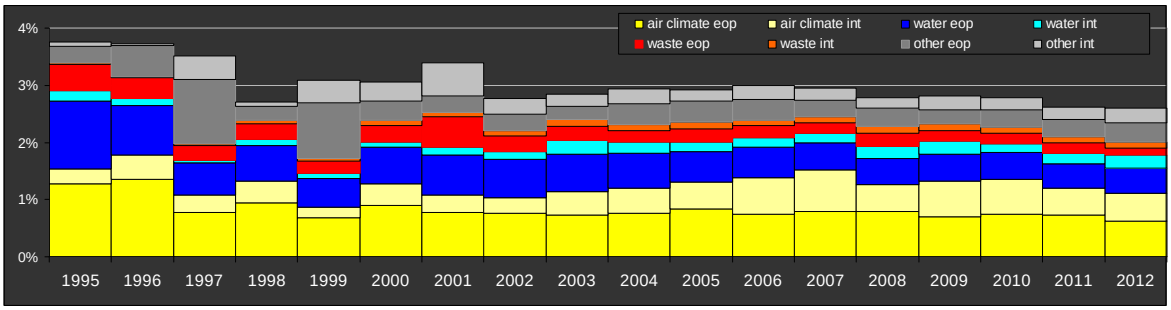


Apparently, before adjusting for inflation, annual environmental investments of manufacturing between 1995 and 2001 have increased from € 5 billion to € 8.5 billion. In the period following – 2002 to 2008 – environmental investments increase gradually from € 6.2 billion to about € 7.5 billion per year. From 2009 to 2012 environmental investments of manufacturing remain stable at slightly less than € 6 billion per year.

About half of environmental investments is to abate air-pollution and climate change, another quarter towards water-pollution. Waste management and other investments make up the rest of the total.

If compared with the total investments of the manufacturing industries, a somewhat different image of the development of environmental investments of the manufacturing industries appears.

Figure 4.5. Relative environmental investment expenditures of the manufacturing industries (Nace C), as share of total sectoral investments, 1995 -2012

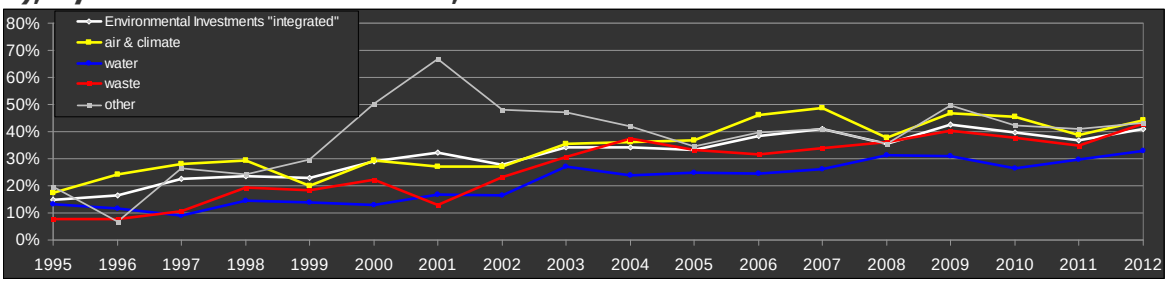


As a fraction of total sectoral investments of the manufacturing industries, a slightly downwards can be observed for the period 1995 – 2012. Whereas in the period before 2002, environmental investments make up over 3% of total investments of manufacturing industries, from 2002 onwards investments range from 2.5% to 3% of total.

Although environmental regulations for industries have become stricter during the period 1995 - 2012, with resulting (large) reductions of most emissions, the abatement costs for industry did not increase or even dropped a little. A plausible explanation for this increased cost-effectiveness of abatement technologies is the technological progress as a result of "eco-innovations". Essentially, businesses become more efficient over time in not just their overall production, but also in making sure that that production meets environmental standards.

During the period 1995 – 2012, the share of process integrated environmental investments in the total environmental investments is increased from about 15% to about 40%. This is shown in figure 4.6.

Figure 4.6. Share of integrated environmental investments in total environmental investment expenditures of the manufacturing sector (Nace C), by environmental domains, 1995 -2012



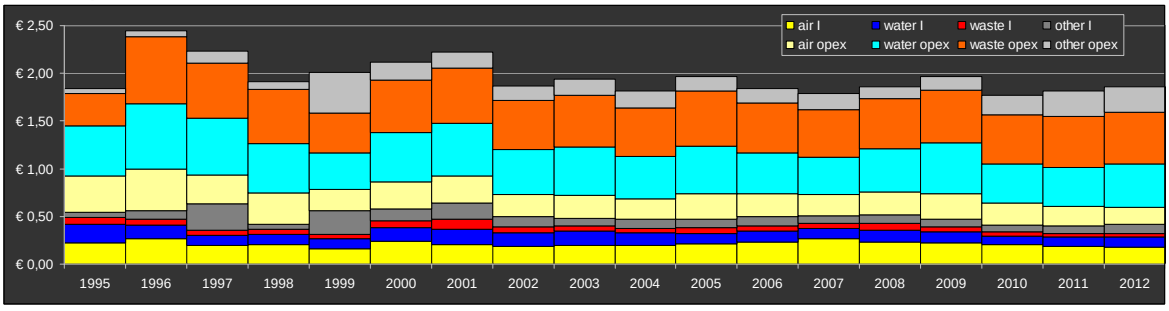
The share of integrated investments in the "air" domain are in most years higher than for the domains "water" and "waste".

Environmental expenditures of the manufacturing industries

If total environmental expenditures, including investments and operational expenditures, are compared with value added of the manufacturing industries, the relative importance and eventual trends in the development of these expenditures, can be analysed.

In figure 4.7, this is done for the manufacturing industries.

Figure 4.7. Relative environmental expenditures (investment and operational) of manufacturing industries (Nace C) in the EU, per € 100 value added, 1995 -2012



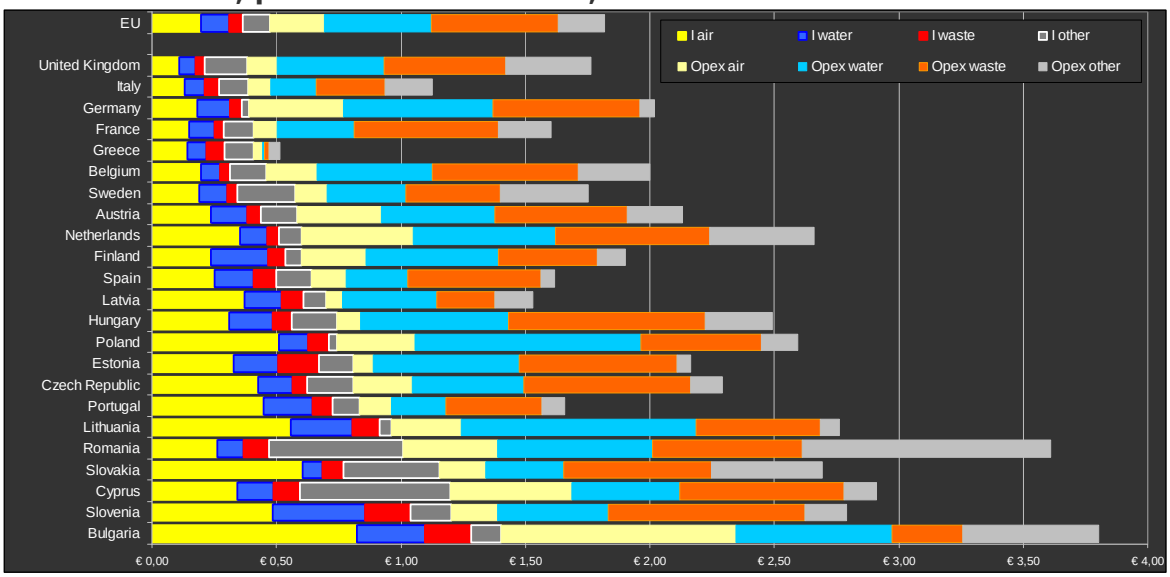
From 2001 onwards, the relative environmental expenditures of manufacturing are lower than € 2. A slightly downwards trend can be observed during the whole period.

The operational environmental expenditures roughly make up 2/3 of the total, and are mainly focussed on the domains "water" and "waste", which also include external provided services (waste water plants, waste contractors).

Environmental expenditures of manufacturing per member state

Figure 4.8 shows that the differences between observed environmental expenditures for the manufacturing sector in the member states of the EU are large. Average expenditures are €1.8 per €100 value added, with investments making up €0.5 thereof. The lowest expenditures are reported in Greece (€0.50 per €100 value added), the highest in Bulgaria (€3.80).

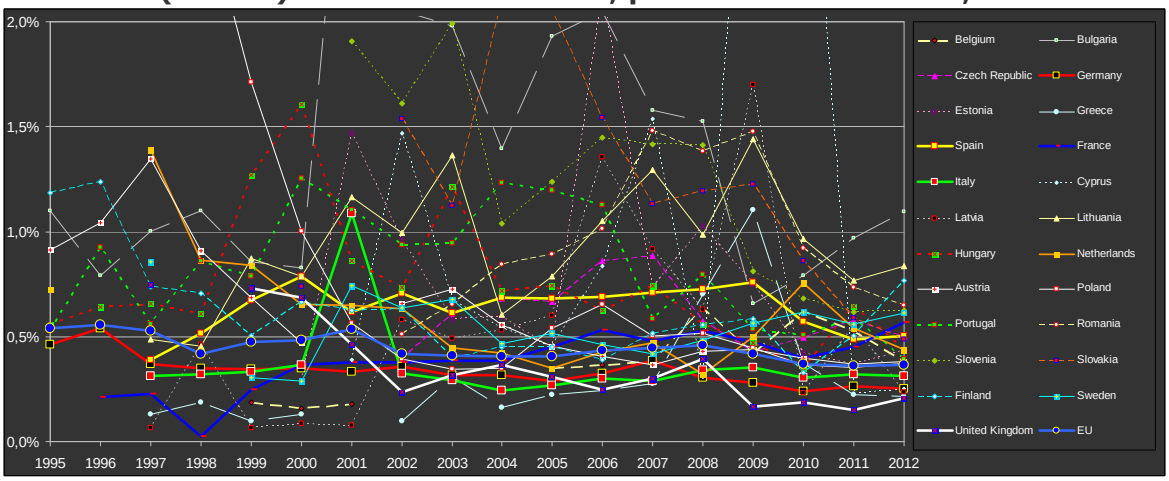
Figure 4.8. Average annual environmental investments (I) and current expenditures (OPEX) of the manufacturing industries (Nace C) in member states of the EU, per € 100 value added, 1995 - 2012



In general, environmental investment expenditures of manufacturing in the "older" member states member states are lower, and in "newer" member states are higher. For operational expenditures there are as well "old" and "new" member states with higher and with lower than average expenditures.

Figure 4.9 gives detailed information on the environmental investment expenditures in the manufacturing sector in different member states.

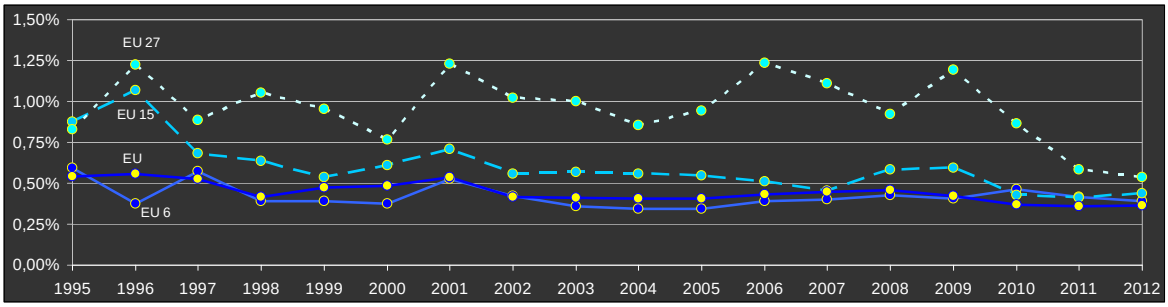
Figure 4.9. Relative environmental investments of the manufacturing industries (Nace C) in EU member states, per € 100 value added, 1995 - 2012



To assess if any regional differences can be observed, the EU member states are grouped in three groups:

- EU 6: Germany, France, Italy, Netherlands, Belgium;
- EU 15: United Kingdom, Spain, Portugal, Greece, Austria, Sweden, Finland;
- EU 27: Poland, Hungary, Czech Republic, Slovakia, Slovenia, Estonia, Latvia, Lithuania, Cyprus, Romania, Bulgaria.

Figure 4.10. Relative environmental investments in the manufacturing sector in the EU, per € 100 value added, 1995 - 2012



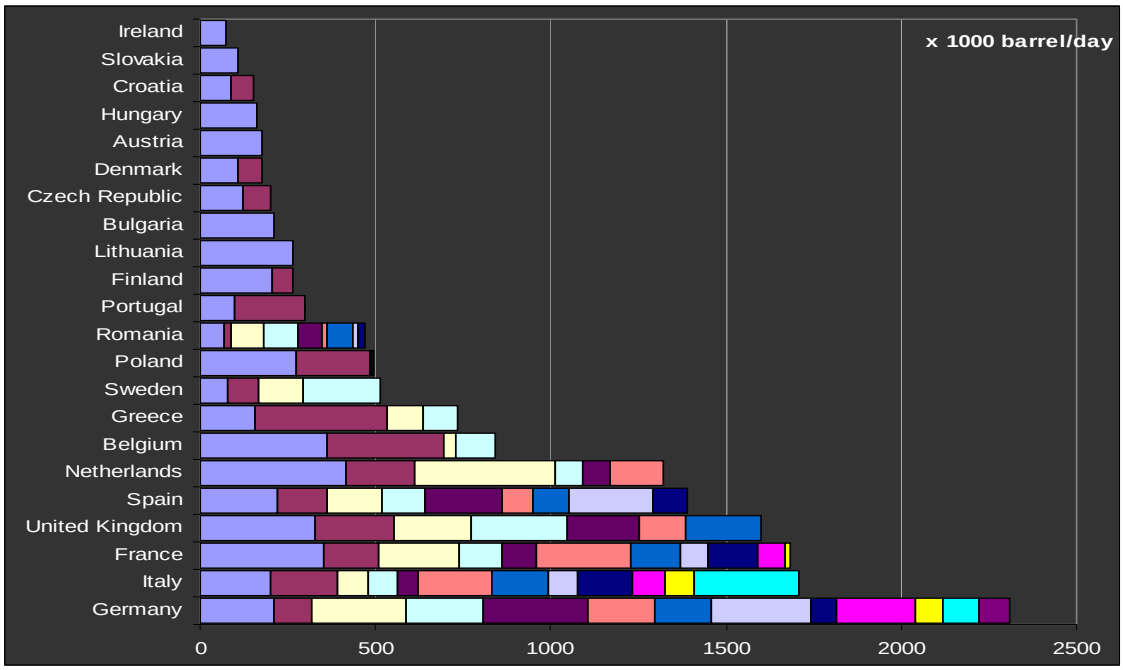
This figure shows, that the relative environmental investments in the "old" member states (EU 6) are lowest, from 0.6% in 1995 to 0.4% in2012, which is about the EU average. In "second wave" member states (EU 15) relative investments drop from 1.1% in 1996 to 0.45% in 2012. In the "new" member states (EU 27) relative investments were "high" until 2010 (between 0.75% and 1.25%), but near the EU average in 2012.

Refinery sector

Overview refinery sector

In 21 member states of the EU, one or more refineries are in operation. In total, about 100 refineries are in operation (Figure 5.1). Most refineries are in Germany (13), which also has the highest refining capacity. Italy (12), France (11) and the United Kingdom (7) follow.

Figure 5.1. Capacities of oil refineries in the EU (2014)



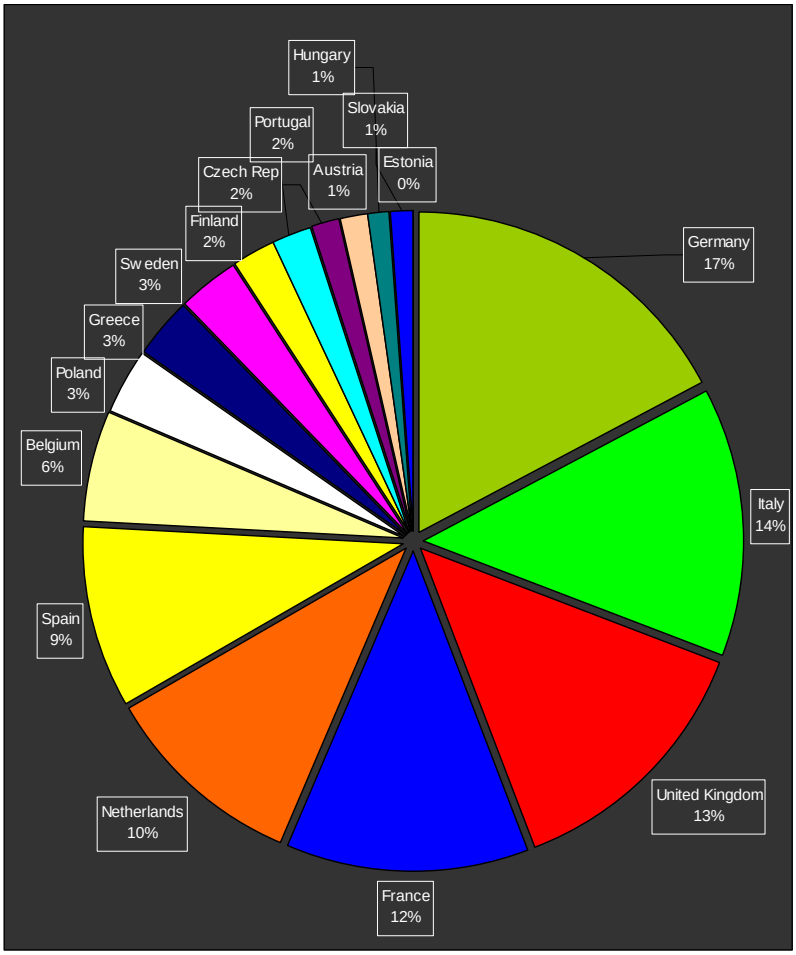
based on "Oil and Gas Journal" (2015)

The average capacity of the refineries is about 150,000 barrels per day. The largest refineries in the EU are situated in the Netherlands (Rotterdam-Pernis): Shell-refinery (416,000 barrels per day) and the BP-refinery (400,000 barrels per day).

On average, in the period 1995 – 2012, annually 680 ktoe[16] crude oil has been refined in these refineries. 6 countries produce 75% of all refined oil products, as can be seen in figure 5.2.

[16] toe = tonnes of oil equivalents, this equals approximately 7.1 – 7.4 barrels of oil.

Figure 5.2. Oil refined in the member states of the EU (1995-2012, average), based on data of the International Energy Agency (IEA, 2015).



Over 75% of oil refining capacity can be found in 6 member states: Germany, Italy, UK, France, Netherlands, Spain.

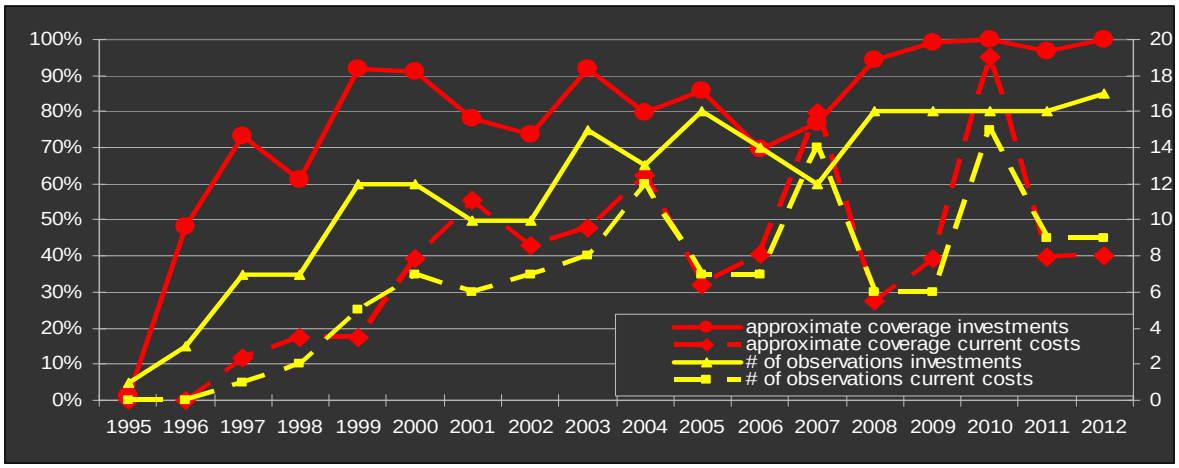
Coverage of data

The number of observations of data on environmental investment expenditures has increased from 1 country in 1995 to 17 countries in 2012 (Figure 5.3). In total 17 of the 21 countries with refineries submitted data (for one or more years) on environmental expenditures in the oil refining sector.

The coverage of the statistical sample is estimated. This has been done by comparing the crude oil refined by refineries in countries that submitted data (on environmental expenditures), with the total amount of crude oil refined in the EU.

It is estimated that the data on investments in the statistical sample represent approximately of 70% or more of the total for almost all years (since 1997). For the last 5 years the coverage is estimated at over 90%.

Figure 5.3 Approximate coverage of data on environmental expenditures of oil refining sector (Nace C19) in the EU, on basis of value added in member states and number of member states submitting data, 1995 – 2012



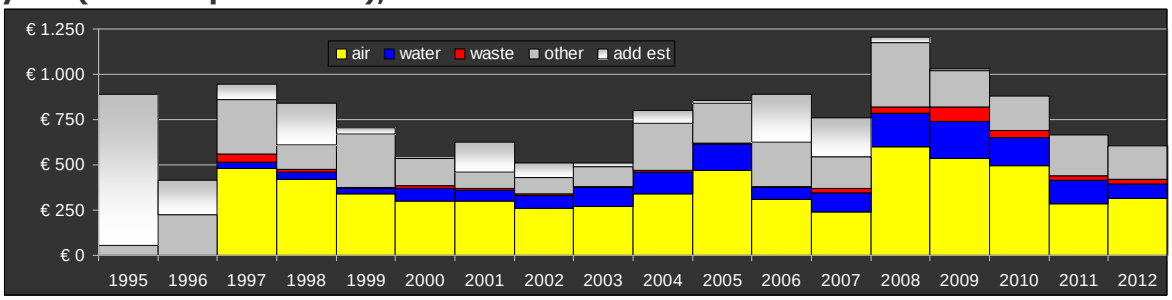
For operational environmental expenditures the coverage is lower: from 2000 onwards, the coverage fluctuates between 30%and 80%. Also, the number of observations on current environmental costs is less than for investments.

The higher the coverage, the more representative (and reliable) the results of the analysis are for the refinery sector in the entire EU.

Environmental investments of refineries in the EU

In 2008, the highest environmental investment expenditures of refineries ever in the EU have been observed, with a total of € 1.1 billion, but in the period following, absolute expenditures dropped by almost 50% as can be seen in figure 5.4.

Figure 5.4. Observed and additional estimated absolute annual environmental investments of refineries in the EU per environmental domain, in € million per year (current price level), 1995 - 2012



As data on absolute environmental investments is incomplete, additional environmental investments are estimated by using the "coverage" percentages, presented in the previous section to arrive at estimated investment totals for the refnineries in the EU.

For the period 1995 – 2012, three trends for environmental investments can be observed:

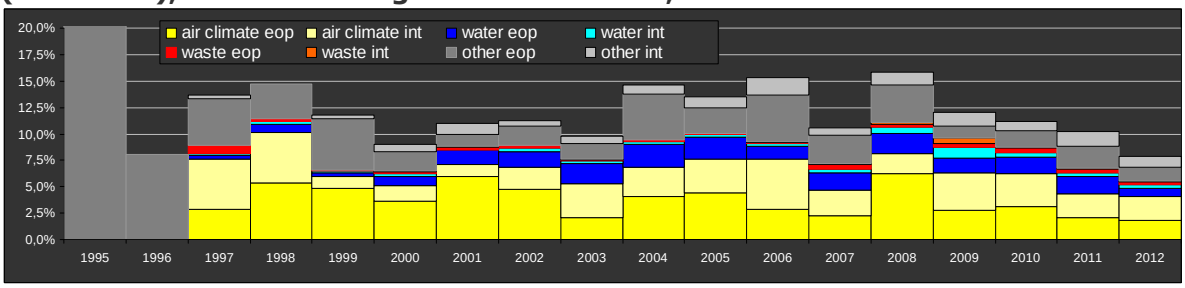
- 1997-2003: decreasing from a peak of € 900 million in 2007 to a low of € 500 million in 2003;

- 2004-2007: investments relative stable between € 750 - € 850 million per year;
- 2008-2012: from a peak of € 1.2 billion in 2008 to a low of € 600 million in 2012.

If environmental investments are compared with the total investments or the amount of crude oil refined, the development of the relative importance of environmental investments can be presented.

As can be seen in figure 5.5, the trends observed for the absolute investments, are less clear or even absent.

Figure 5.5. Relative environmental investments of the oil refining sector (Nace C19), as % of total gross investments, 1995 - 2012

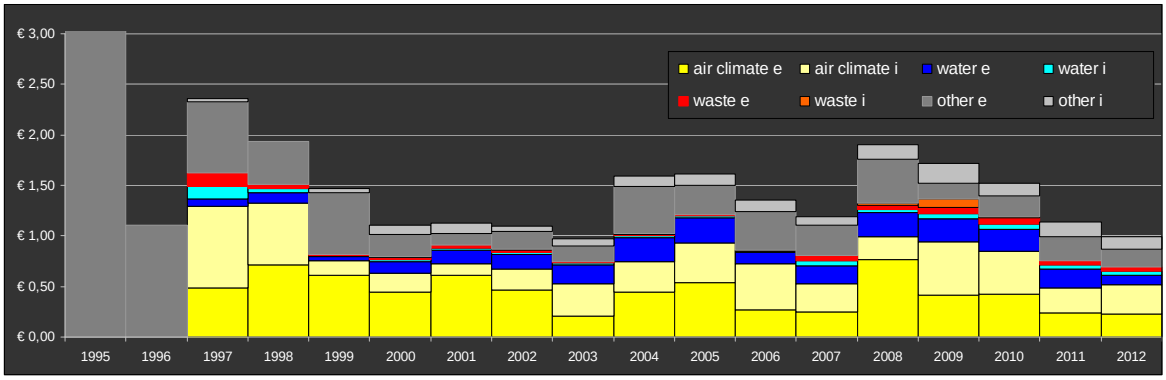


In some of the years the relative environmental investments peak (between 13 and 16% of total investments): (1995), 1997, 1998, 2004-2006 and 2008. In the other years, environmental investments range from 8% to 12% of total sectoral investments. The sharp decrease of relative environmental investments after 2008 is similar to the one observed for absolute environmental investments.

This analysis (excl. 1995) shows that the environmental investments form between 8% - 16% of total investments in the refinery sector. The decrease of relative environmental investments between 2008 and 2012 can also be observed.

Another way to assess trends is to compare environmental investments with the amount of crude oil refined. The International Energy Agency (IEA) publishes figures on the amounts of crude oil refined, using "tonnes of oil equivalents" (toe)[17]. 1 toe is approximately equal to 7 barrels of oil.

Figure 5.6. Relative environmental investments per toe of oil refined (fixed price level 2012), 1995 - 2012



[17] 1 tonne of crude oil = 1 toe, this unit (toe) is also used for other energy-resources like natural gas, etc. 1 toe is equal to 7.1 barrel (of oil).

This analysis shows that in the period 1996 – 2012, environmental investments "peaked" three times, in 1997 (€ 2.30 per toe), 2004-2005 (€ 1.60 per toe) and in 2008 at € 1.90 per toe crude oil refined. In most other years, relative investments range between € 1.00 and € 1.50 per toe crude oil refined.

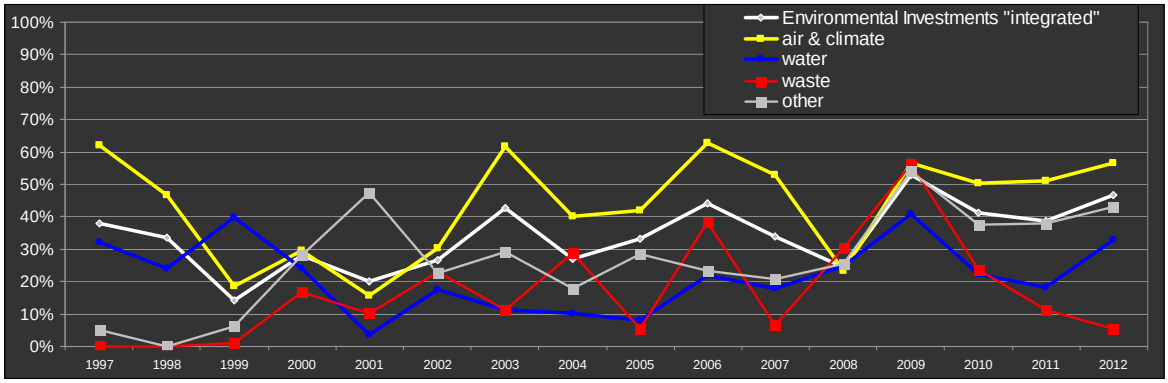
If the environmental investments are compared to the market price of crude oil – which ranges from roughly € 40 to over € 100 per barrel (or roughly € 300 to € 700 per toe) – it can be seen, that the investments, relative to the oil-price, are fairly small (between 0.15% and 1.5%).

Two types of environmental investments are distinguished:

- End-of-pipe investments, like filters, etc.
- Process integrated investments.

Since 1997 data on integrated environmental investments are collected by most of the responding countries.

Figure 5.7. Share of integrated environmental investments in total environmental investment expenditures of the oil-refining industries (Nace C19), by environmental domains, 1995 - 2012



The presented results show, that from 1997 onwards, integrated investments form – with a few exceptions - a significant part of total environmental investments. Apparently, the share of these investments increased slightly in the period 1997 – 2012, from less than 40% to between 40% and 50%, although the pattern is irregular.

The domain "air" has the highest level of integrated environmental investments.

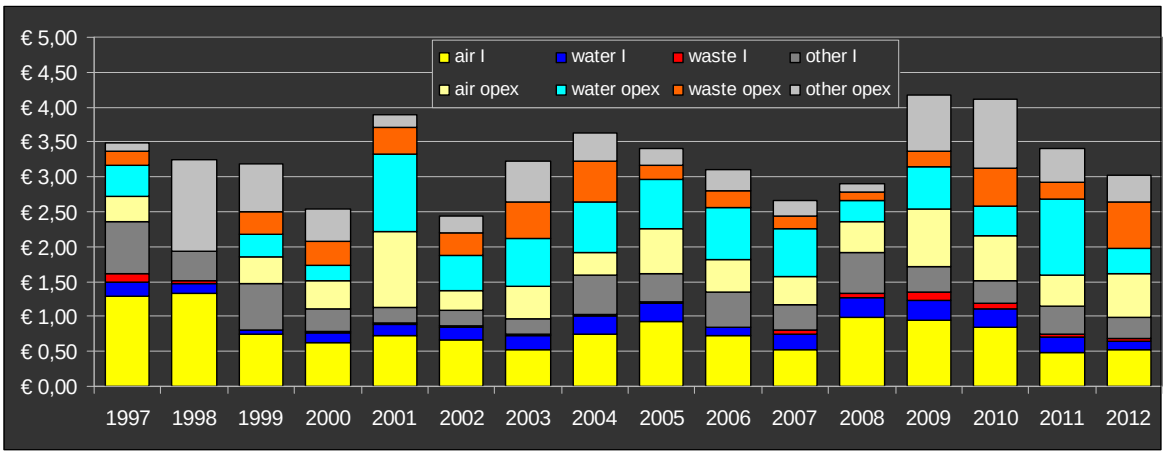
Environmental expenditures of refineries in the EU

In about 50% of the cases, also information on the current environmental expenditures of refineries in member states is available. By combining the information on relative environmental investments with current environmental expenditures, the development of relative total environmental expenditures in the refinery sector in the EU can be estimated. This leads to the following figure 5.8, in which the environmental investments and operational expenditures are related to the input of crude oil in the refinery sector.

The results indicate that the total relative environmental expenditures fluctuate from about € 2.50 to € 4.00 per toe crude oil refined. There is no obvious upward or downward trend over the whole period 1997 – 2012. However, for shorter periods, certain trends can be observed. For example. during the first years, the relative

expenditures seem to decrease (from € 3.5 to € 2.5). Also during the last years, there seems to be a downward trend.

Figure 5.8. Relative investment and operational environmental expenditures of refineries in the EU, per toe crude oil refined (fixed prices 2012), 1995 - 2012



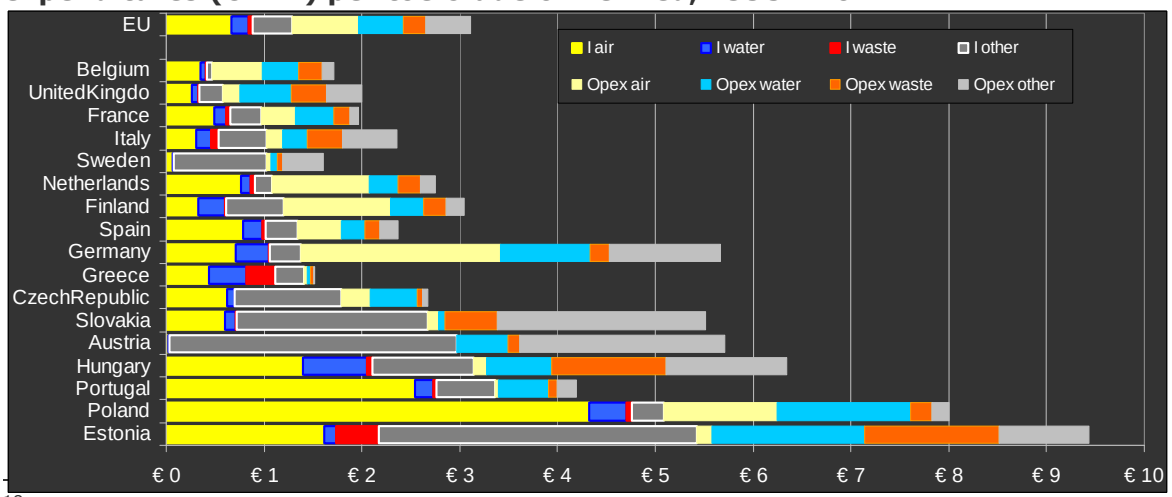
The results also indicate that the relative operational environmental costs of refineries during the period 1997 – 2012 increase from about € 1.00 - € 1.50 per toe in the early years, to about € 2.0 - € 2.5 per toe by the end of the period. However, it should be noted that for some years, due to the relative small sample (for example only 6 of 17 potential observations), the results may be biased. For example, for 2001 6 observations are available, of which 2 show high (> € 4 per toe) relative current expenditures, largely influencing the result for 2001.

A possible explanation for the trends observed, can be that "peaks" in expenditure occur due to large investments (to comply with stricter standards), whereas enterprises will seek opportunities to save on operational costs (which also may be caused by innovative investments, which can result in lower current costs).

Environmental expenditures per country

In Figure 5.9 the average annual environmental expenditures per toe oil refined are presented per country. The countries are sorted by the annual average environmental investments.

Figure 5.9. Average annual environmental investments (I) and current expenditures (OPEX) per toe crude oil refined, 1995 - 2012[18]



[18] For Estonia, instead of crude oil, oil shale is refined, apparently leading to higher unit investments and operational expenditures.

The average annual environmental investments in "older" member states are more or less comparable (France, Italy, Finland, Netherlands, Greece, Sweden, Spain, Germany) and are in the range of € 1.0 to € 1.6 per toe crude oil refined.

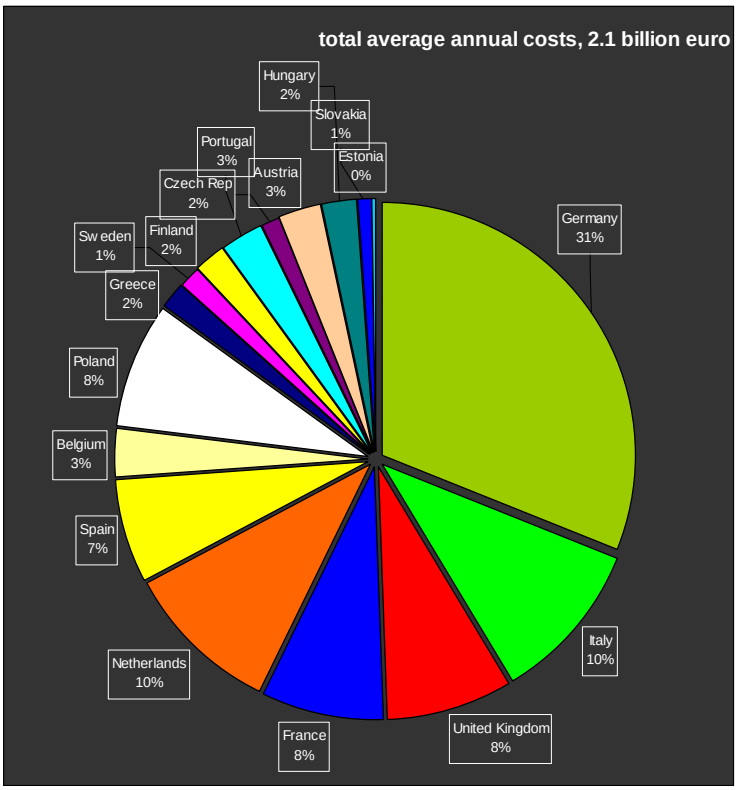
In "newer" member states (Czech Republic, Poland, Hungary, (Austria), (Portugal), Slovakia) the average annual investments range between € 2 and € 5 per toe crude oil refined.

A possible explanation for this difference in average investments is that in "newer" member states, refineries had less time to adapt to the EU-standards than in "older" member states. Another factor may be that the refineries in the "newer" member states are relatively smaller compared with those in for example Germany, UK, France, Italy.

For the average annual current costs[19], differences between member states are larger. For Germany, this difference is remarkable: average annual current costs are about € 4.50 per toe, whereas in France, Italy, UK, Finland and the Netherlands, the annual current costs are significantly lower at between € 1.0 and € 2 per toe.

In most cases, current costs are higher than the investments.

Figure 5.10. Environmental expenditure (investments and current expenditures) of refineries in EU countries, average 1995-2012

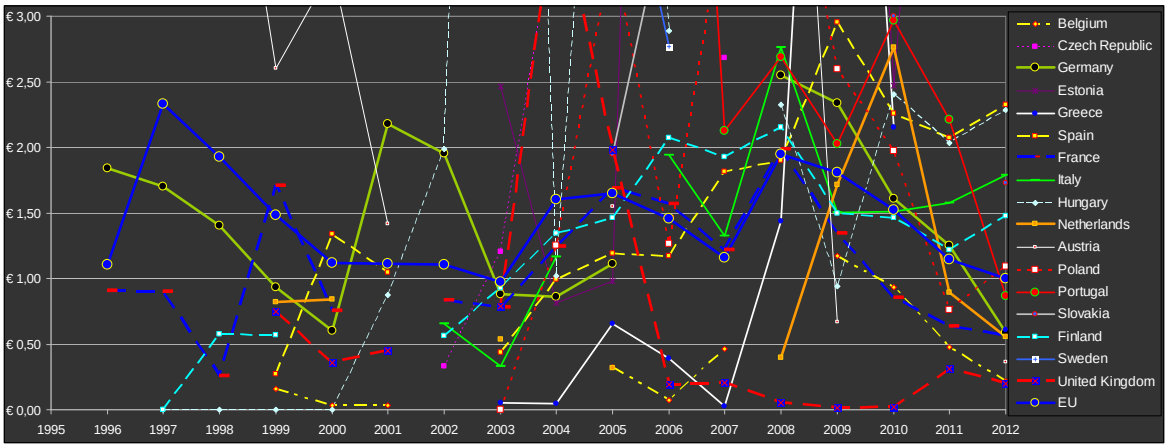


In the period 1995 – 2012, on average, refineries in the EU spent each year about € 2.1 billion to protect the environment. Highest expenditures are measured in Germany (31% of total). Almost 75% of the protection expenditures is concentrated in just 6 member states, reflecting the difference in capacity between countries.

Figure 5.11 gives detailed information on the environmental investment expenditures in refineries in different MS. It shows that the development thereof is very irregular. Years or periods with high levels of environmental investments are followed by years with lower investments. It seems that no general trend(s) can be observed.

[19] For current costs less observations are available than for investments.

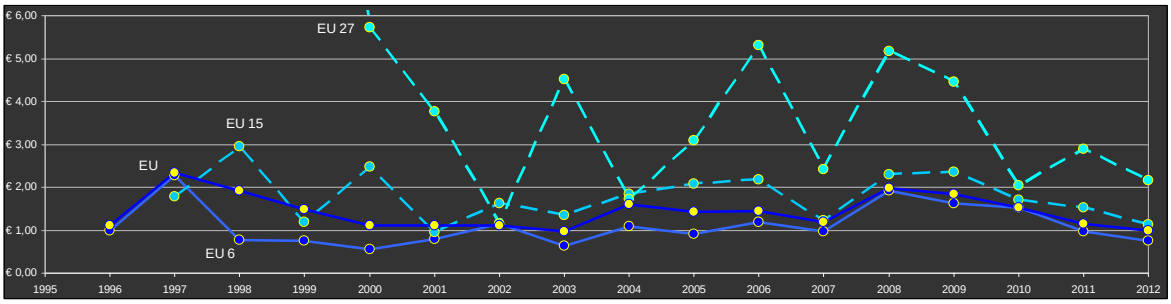
Figure 5.11. Relative environmental investments of the refinery sector (Nace 19) in EU member states, € per tonne crude oil refined, 1995 - 2012



To assess if regional differences can be observed, the EU member states are grouped in three groups:

- EU 6: Germany, France, Italy, Netherlands, Belgium;
- EU 15: United Kingdom, Spain, Portugal, Greece, Austria, Sweden, Finland;
- EU 27: Poland, Hungary, Czech Republic, Slovakia, Slovenia, Estonia, Latvia, Lithuania, Romania, Bulgaria.

Figure 5.12. Relative environmental investments in the refinery sector in the EU, € per tonne crude oil refined (fixed prices 2012), 1995 - 2012



This figure shows that the refineries in "old" member states (EU 6) dominate the development of environmental investment expenditures. In "new" member states (EU 27) specific investments are significantly higher, but also in the "second wave" member states (EU 15), specific investments are somewhat higher than the EU average.

Environmental costs of refineries in the Netherlands

Data on the environmental expenditures of industry in the Netherlands, including refineries, dates back to 1979. In this year, the CBS started collecting data on environmental expenditures of manufacturing industries in 1979. For each of the manufacturing sectors, time-series on investments have been collected from 1974 onwards. Also, methods were developed to assess annual current environmental costs.

CBS has developed a way to present annualised environmental expenditures, by calculating capital costs (depreciation and interest) in a standardised way (see chapter

on methodology). This enables the presentation and analysis of relative long time-series (22 years).

In the next figure, total environmental costs of oil-refineries in the Netherlands are shown, in relation to the input of crude oil. Costs are expressed in € per toe (tonne oil equivalent), comparable to about 7 barrel of crude oil.

From 1990 to 1997, annualised costs were around € 2.50 per toe oil refined. In 1998 there is a sharp increase in costs to about € 4 per toe. Costs peak in 2007, at € 5 per toe. After 2007, annualised costs decrease rapidly again, to slightly higher than € 3 per toe.

Figure 5.13. Annualised environmental expenditures (capital costs and operational costs) of oil refineries (Nace C19) in the Netherlands, € per toe (price level 2012), 1990 - 2012

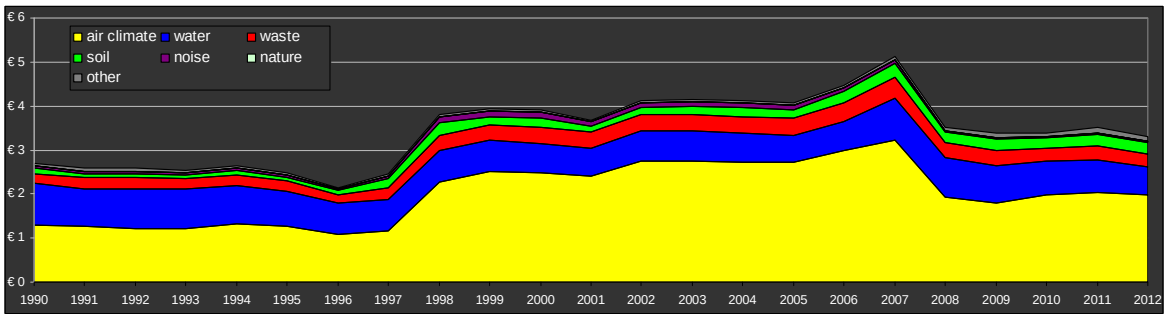
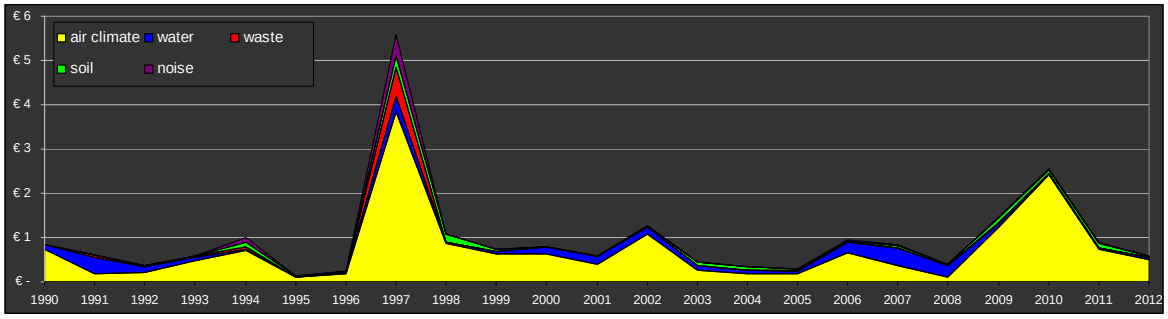


Figure 5.14 shows that the environmental investments of the refineries in the Netherlands peaked in 1997 and (to less extent) in 2010. This explains partly, why annualised costs increased after 2007.

Figure 5.14. Annual environmental investments of oil refineries (Nace C19) in the Netherlands, € per toe (price level 2012), 1990 - 2012



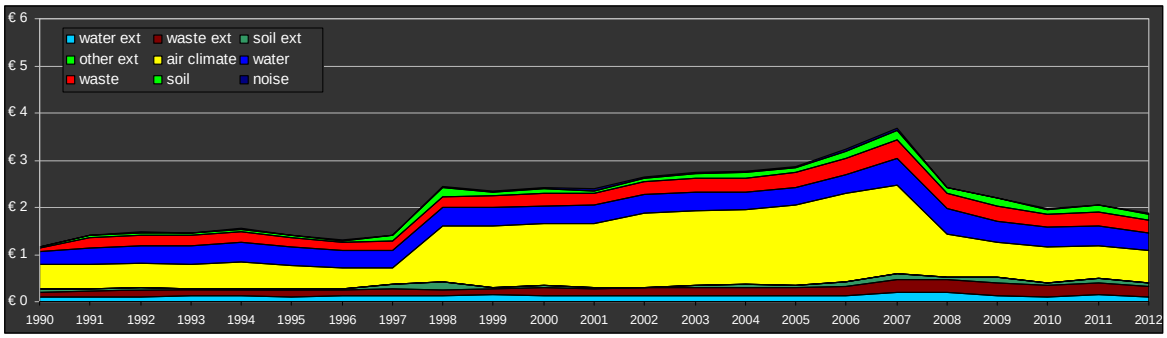
The development of the current costs follows more or less the same pattern as total annualised environmental costs. This is mainly due to the fact that higher (environmental) capital intensity in the refinery sector (after 1997), leads to higher internal operational costs[20]. After 2007 the large investments of 1997 have been written off (for a large part), leading to decreased capital costs and also decreased internal operational costs.

In Figure 5.15 external current expenditures (waste management, water management, soil sanitation, outsourced research, etc.) are separately presented. It

[20] CBS calculated (up to 2011) the internal operational costs (of own environmental investments) in relation to the capital stock. From 2012 onwards, these costs are not calculated anymore. The current costs presented in Figures 16 for 2012 are extrapolated from 2010-2011.

can be seen that these costs form only a relative small part of total current costs: € 0.26 per toe (1990) , € 0.60 (2007) and € 0.40 per toe (2012).

Figure 5.15. Annual operational environmental costs of oil refineries (Nace C19) in the Netherlands, € per toe (price level 2012), 1990 - 2012



For the refinery sector in the Netherlands 3 periods can be distinguished:

- 1990 – 1997: relative low costs of € 2.50 to € 3 per toe and low investments (< € 1 per toe);
- 1997 – 2007: relative higher costs of between € 3.80and € 5.10 per toe, after large investments in 1997;
- 2008 – 2012: somewhat lower costs of between € 3.30 and € 3.50 per toe.

There are a few possible explanations for the observed patterns of specific environmental costs and investments:

- large investments (1997, mainly "air") needed to comply with stricter standards leading to higher capital costs afterwards and also increased operational costs.
- changes in process, reducing operational costs for "air" after 2007.
- automation of installations, leading to lower labour costs and more efficient use of resources (internal operational costs);
- increasing costs of external environmental services ("waste", "water", etc.).

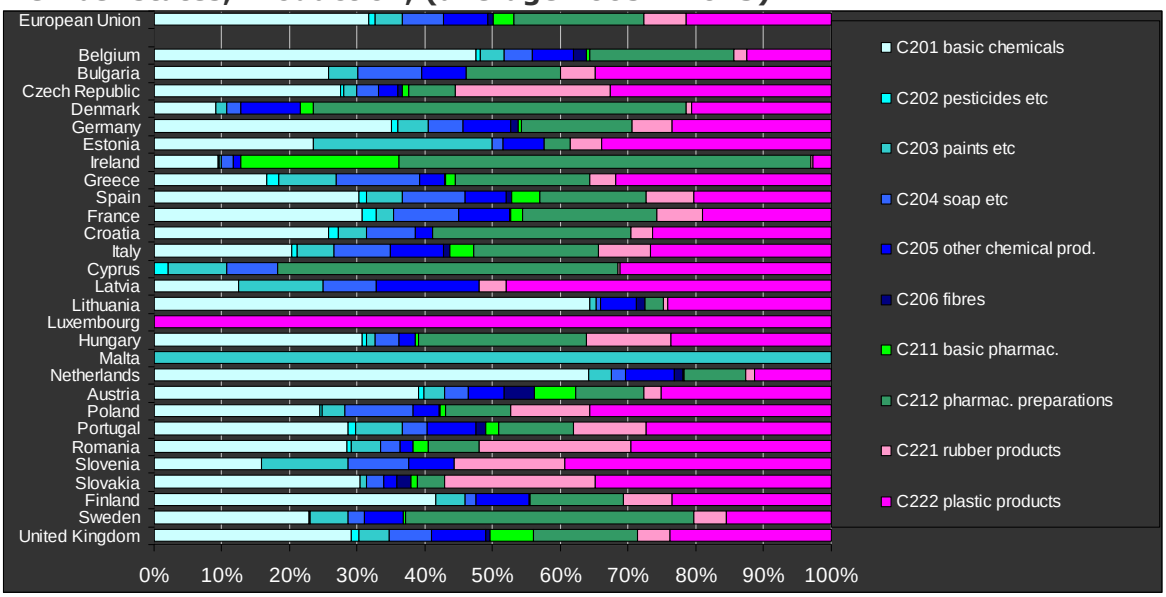
Chemical industry

The chemical industry is an essential part of the EU economy. It produces an almost uncountable number of products used in daily life of citizens and a wide variety of intermediate products for all industries. The chemical sector in the EU generated in 2012 a total value added of € 270 billion.

In this case study, environmental expenditures of the chemical sector (Nace C20 – Nace C22) as mentioned below are analysed. The chemical sector comprises:

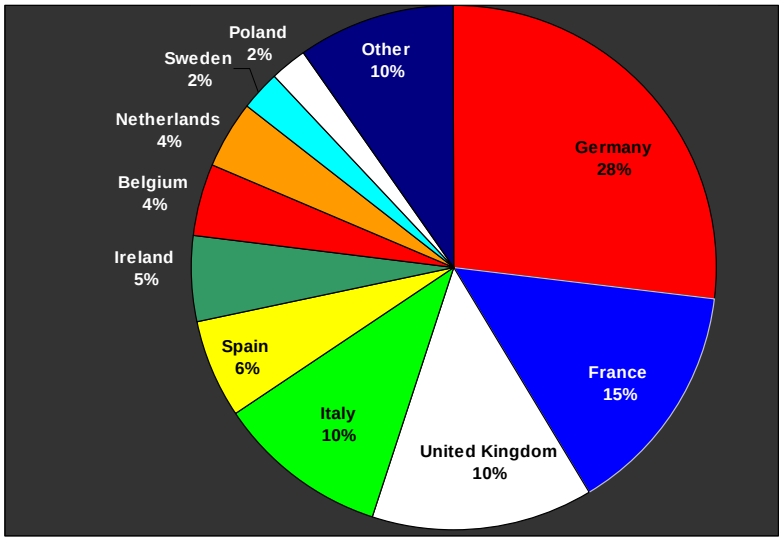
- Nace C20: Manufacture of chemicals and chemical products:
  - Nace C201: Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms;;
  - Nace C202: Manufacture of pesticides and other agrochemical products;
  - Nace C203: Manufacture of paints, varnishes and similar coatings, printing ink and mastics;
  - Nace C204: Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations;
  - Nace C205: Manufacture of other chemical products;
  - Nace C206: Manufacture of man-made fibres;
- Nace C21: Manufacture of basic pharmaceutical products and pharmaceutical preparations:
  - Nace C211: Manufacture of basic pharmaceutical products;
  - Nace C212: Manufacture of pharmaceutical preparations;
- Nace C22: Manufacture of rubber and plastic products:
  - Nace C221: Manufacture of rubber products;
  - Nace C222: Manufacture of plastics products.

Figure 6.1. Structure of the chemical sector (Nace C20, C21, C22) in EU member states, Production, (average 2005 – 2013)



The structure of the chemical sector in the EU member states is presented in figure 6.1. This shows a large variety of this sectors' structure in the different member states.

Figure 6.2. Value Added generated by the chemical sector (Nace C20 – C22) in member states of the European Union, Average 1995-2012

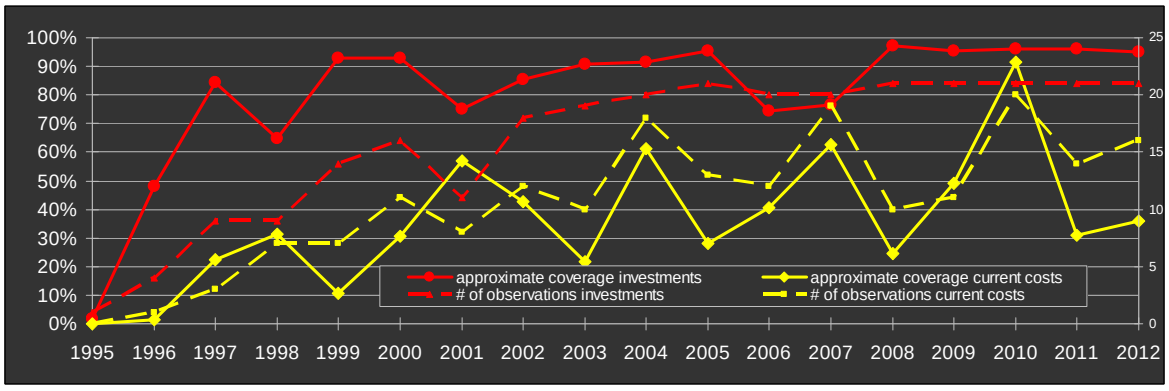


This figure shows that 5 large member states and 1 small (Ireland) are responsible for 75% of total value added generated in the EU chemical sector.

Data coverage

In total, 21 of the 28 member states of the EU, have submitted data on the environmental expenditures of the chemical sector for one or more years. As can be seen in figure 6.3, more data on environmental investments than on current expenditures have been submitted.

Figure 6.3. Approximate coverage of the data on environmental expenditures of the chemical industrial (Nace C20 – C22) sector in total in the EU, on basis of value added in member states of the sectors studied and number of member states submitting data, 1995 - 2012

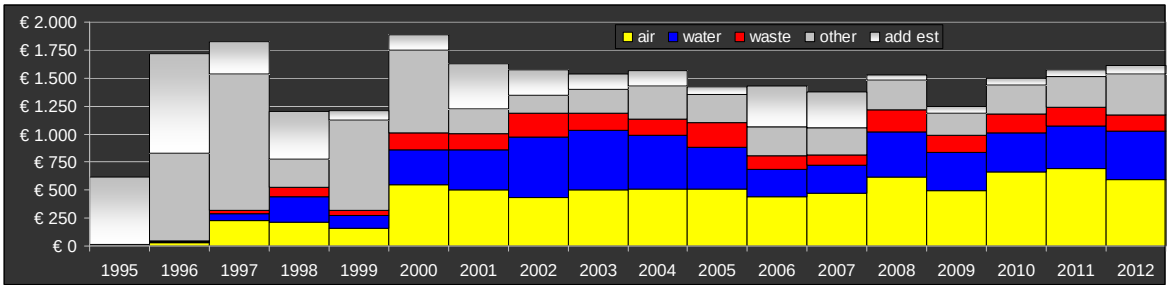


Measured by value added, data on environmental investments cover in most years over 80% of the sector in the EU. Coverage for operational expenditures is (much) lower: in only one year (2010) the coverage is over 90%, in many other years the coverage is as low as 20% - 40%.

Environmental investments of the chemical sector

As data on absolute environmental investments is incomplete, additional environmental investments are estimated by using the "coverage" percentages, presented in the previous section to arrive at estimated investment totals for the chemical sector in the EU. The resulting estiamted absolute environmental investments are presented in figure 6.4.

Figure 6.4. Observed and additional estimated absolute annual environmental investments of the chemical industries sector (Nace C20-C22) in the EU per environmental domain, in € million per year (current price level), 1995 - 2012



In 2000, the highest environmental investment expenditures of the chemical sector in the EU have been observed, with a total of over € 1.8 billion. In the period following, absolute investment expenditures are somewhat lower at around € 1.5 billion, as can be seen in figure 6.4. Investments for "air" are most important, followed by "water" and "other".

There is no clear trend visible in the absolute investments, other than that environmental investments of the chemical sector do not necessarily increase.

The following figure shows the relative environmental investments, as share of total gross investments of the chemical sector in the EU (average € 38 billion per year).

Figure 6.5. Relative environmental investment expenditures of the chemical industries sector (Nace C20-C22), as share of total sectoral gross investments, 1995 - 2012

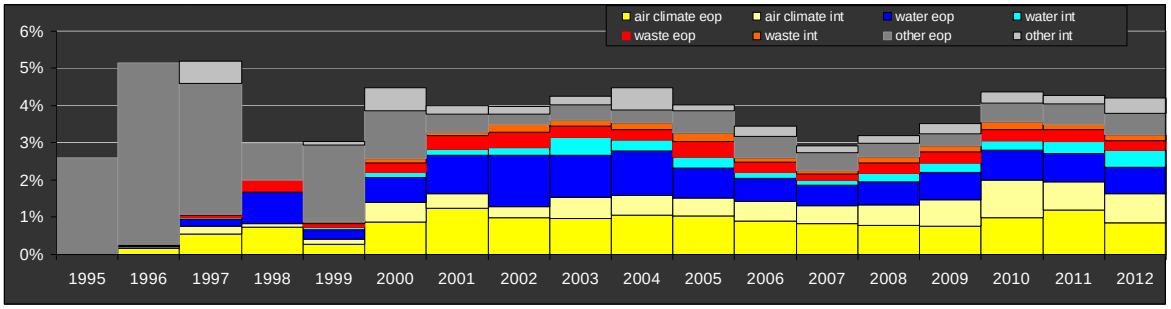


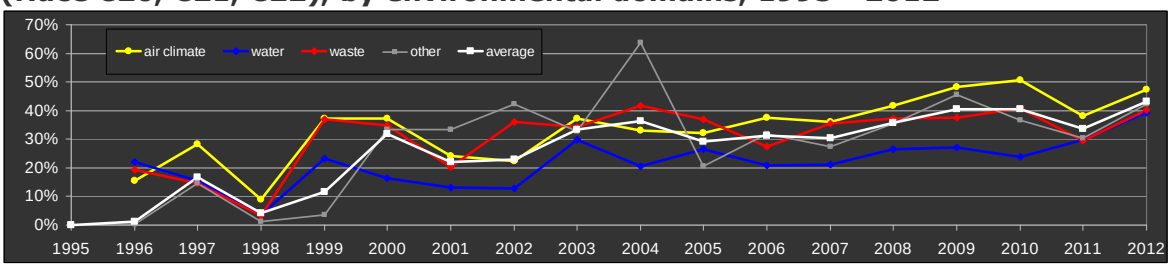
Figure 6.5 shows that the specific environmental investments of the chemical sector range between 3% and 5%, with a peak in 1997.

Two types of environmental investments are distinguished:

- "end-of-pipe" investments, like filters, etc.
- "process integrated" investments, which are integrated into process technology.

Since 1997 data on integrated environmental investments are collected by most of the responding countries. The presented results show, that integrated investments form a significant part of total environmental investments.

Figure 6.6. Share of integrated environmental investments in total environmental investment expenditures of the chemical industrial sector (Nace C20, C21, C22), by environmental domains, 1995 - 2012



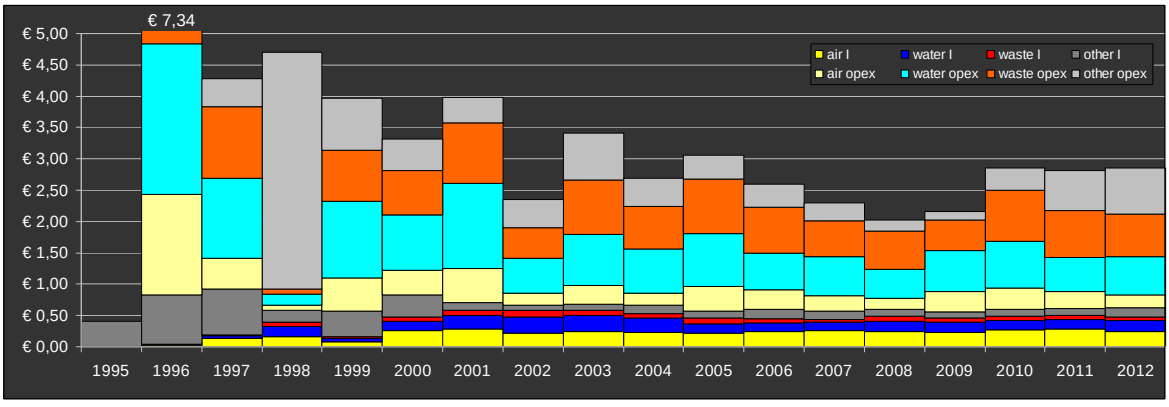
The share of integrated investments increased in the period 1997 – 2012, from about 15% to 40% in 2012, which is also highest level ever. The trend general observed is also visible for the different environmental domains, although for ”air” and “waste” as early as 1999, the level of integrated investments already was 40%.

Environmental expenditures of the chemical sector

Data on operational environmental expenditures of the chemical sector are as such, that an absolute representation of the total environmental expenditures (investments and operational) would provide an incomplete picture of these expenditures.

Therefore, total environmental expenditures are compared to the value added of the chemical sector, for the countries that have submitted data. This results in specific environmental expenditures per € 100 value added generated by the chemical sector, which are presented in figure 6.7.

Figure 6.7. Relative environmental expenditures (investment and operational) of the chemical industrial sector (Nace C20-C22), per € 100 value added, 1995 - 2012



Over the period 1996 – 2012, the specific environmental expenditures decrease in an irregular pattern. The specific investments show from 2000 onwards a decreasing trend (from € 0.80 to € 0.60). The pattern for specific operational expenditures is less regular.

The fluctuation of the specific operational expenditures is due to the low coverage of operational expenditures in most years (the absence of most data for larger member

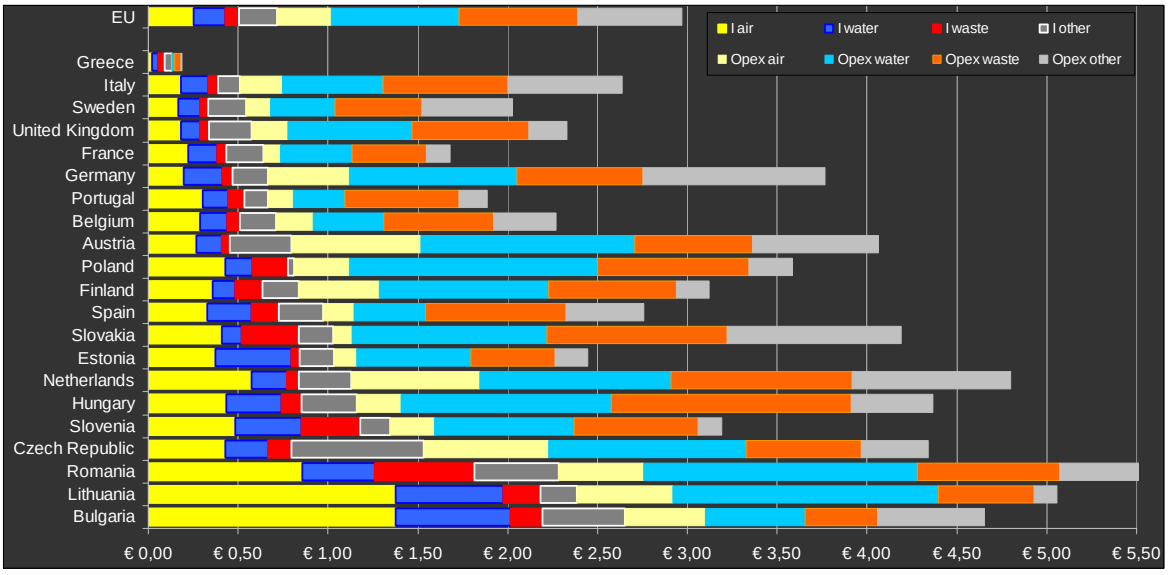
states). For the 4 years with a relative high coverage (> 50%: 2001, 2004, 2007 and 2010), specific operational expenditures are in the range from € 3.25 (2001) to € 1.75 (2007) per € 100 value added. It looks as if – after low operational expenditures in 2007 – the specific operational expenditures stabilize around € 2.25 (in 2010).

Operational expenditures in the domains "water" and "waste" are the most important for the chemical sector.

Environmental expenditures in the chemical sector per member state

There is a large variation in the specific environmental expenditures of the chemical sector in member states of the EU (excluding Greece): from € 1.70 per € 100 value added to over € 5.50. The average is € 3 per € 100 value added, of which € 0.70 investments and € 2.30 operational expenditures.

Figure 6.8. Average annual environmental investments (I) and current expenditures (OPEX) of the chemical industrial sectors (Nace C20 – C22), per € 100 value added, 1995 - 2012



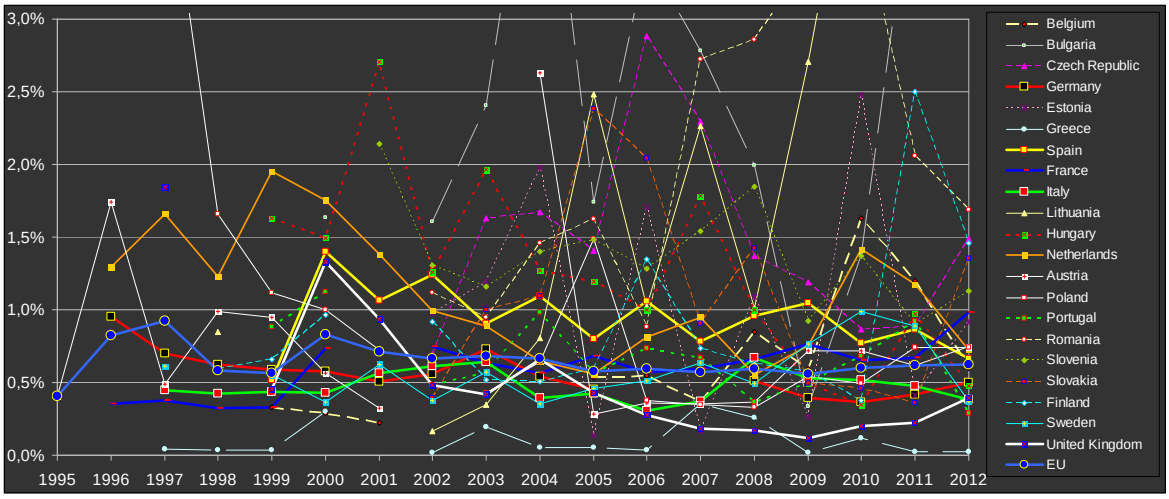
Of the largest 6 member states, only the chemical sector in Germany has higher than average specific environmental expenditures. The chemical sector in France has the lowest specific expenditures, € 1.70 per € 100 value added.

The largest variations can be observed for the specific expenditures of the chemical sector in the various member states.

Figure 6.9 gives detailed information on the relative environmental investment expenditures of the chemical sector in member states. It shows that the development thereof is very irregular. Years or periods with high levels of environmental investments are followed by years with lower investments.

Although the EU-average shows a somewhat decreasing trend, this trend is not obvious for all member states, especially for newer member states, specific investments are often (much) higher than the EU-average.

Figure 6.9. Relative environmental investments of the chemical industrial sector (Nace C20 – C22) in EU member states, per € 100 value added, 1995 - 2012



To analyse potential regional differences of the specific environmental investments, the EU member states are grouped in three groups:

- EU 6: Germany, France, Italy, Netherlands, Belgium;
- EU 15: United Kingdom, Spain, Portugal, Greece, Austria, Sweden, Finland;
- EU 27: Poland, Hungary, Czech Republic, Slovakia, Slovenia, Estonia, Lithuania, Romania, Bulgaria.

This is shown in figure 6.10.

Figure 6.10. Relative environmental investments in the chemical in the EU, per € 100 value added, 1995 - 2012

Specific environmental investments for the chemical sector in the EU are at the end of the period 1995 - 2012 about 0.6% of value added. This is about the same for the "old" (EU 6) "second wave" (EU 15) member states. Specific investments in the "new" (EU 27) member states are consistently higher – between 1% and 2% of value added – than the EU average.

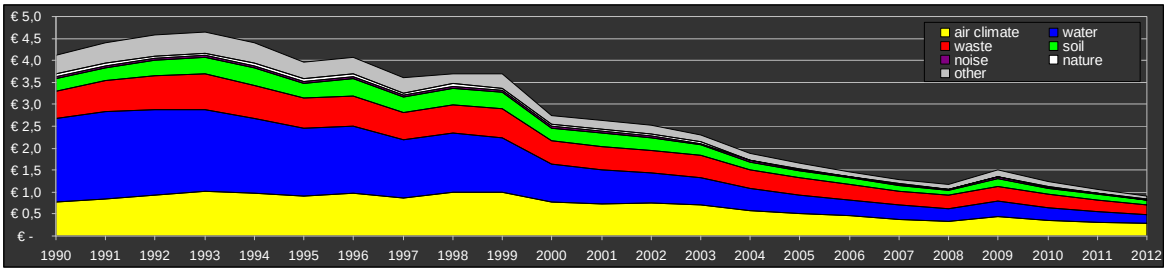
Environmental costs of the chemical sector in the Netherlands

Data on the environmental expenditures of industry in the Netherlands, including chemical industries, date back to 1979. In this year, the CBS started collecting data on environmental expenditures of manufacturing industries in 1979. For each of the manufacturing sectors, time-series on investments have been collected from 1974 onwards. Also, methods were developed to assess annual current environmental costs.

CBS has developed a way to present annualised environmental expenditures, by calculating capital costs (depreciation and interest) in a standardised way (see chapter on methodology). This enables the presentation and analysis of relative long time-series (22 years).

In the next figure, total environmental costs of the chemical sector (Nace 20 – Nace 21) in the Netherlands are shown, in relation to the value added of this sector. Costs are expressed in € per € 100 value added.

Figure 6.11. Annualised environmental expenditures (capital costs and operational costs) of chemical industries (Nace C20-C21) in the Netherlands, € per € 100 value added, 1990 - 2012

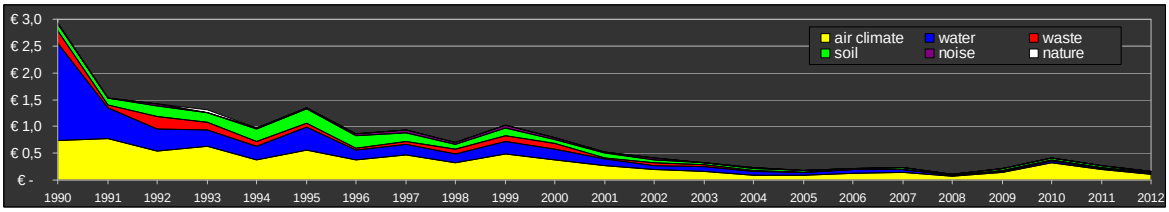


After reaching over € 4.50 per € 100 value added in 1993, the environmental costs of the chemical sector in the Netherlands started to decrease. In 2000 costs drop to € 2.75, in 2012 costs are less than € 1 per € 100 value added.

The development of investments and operational costs, which form the basis for the calculation of total environmental costs for the chemical sector, is shown in the next two figures.

The specific environmental investments of the chemical sector in the Netherlands have been relatively high during the period 1990 – 2001 (between € 3 and € 0.5 per € 100 value added), from 2002 onwards the specific investments are always lower than € 0.5 per € 100 value added and often half of that.

Figure 6.12. Annual environmental investments of the chemical industries (Nace C20-C21) in the Netherlands, € per € 100 value added (price level 2012), 1990 - 2012



The drop of the specific investments from 1990 onwards, partly explains the decreased overall specific environmental costs for the chemical sector.

The next figure shows that the largest impact on the development of the total specific environmental costs is caused by the operational environmental costs.

Figure 6.13. Annual operational environmental costs of chemical industries (Nace C20-C21) in the Netherlands, € per toe (price level 2012), 1990 - 2012

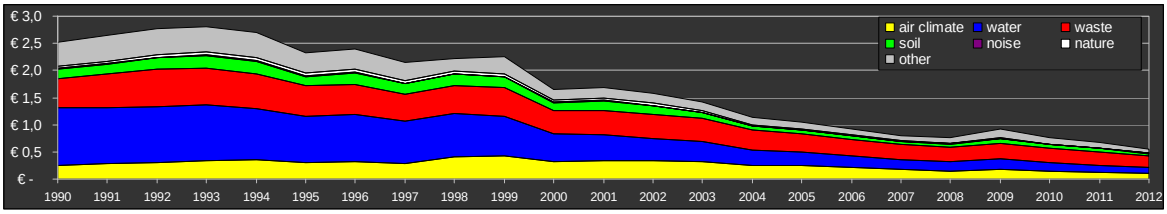


Figure 6.13 shows that specific operational environmental costs drop from € 2.75 in 1993 to € 0.6 in 2012. That is a drop of specific costs of almost 8% per year.

There are various possible explanations for the fast development of the specific environmental costs of the chemical sector in the Netherlands:

- due to technological progress and innovations, specific investment costs tend to decrease in general. There are also indications that this process goes faster for environmental technologies;
- the increasing share of "process integrated" environmental technologies, which decrease investment costs;
- automation, which has affected operations in all economic sectors: less personnel, more efficient use of resources, etc;
- shifts in the production (for example DSM, a large Dutch chemical company, has shifted away from basic chemicals to fine chemicals);
- geographical concentration of many (large) international operating chemical companies in the Netherlands.

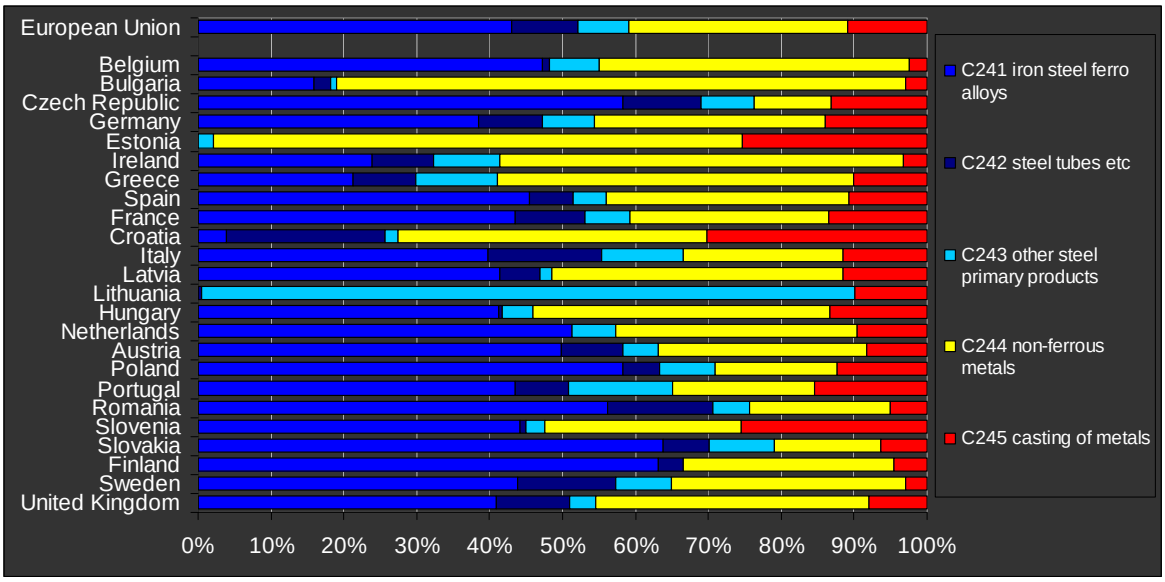
Base metal industry

The base metal industry is an important pillar of the European economy. Many sectors make use of iron and steel: construction, bridges, cars, machines, etc. Also, non-ferrous metals play an important role (i.e. copper in electronics and wiring, etc.).

The total value added generated by the base metal sector in the EU is on average (1995 – 2012) € 62 billion per year, for 2012 € 57.5 billion.

The structure of the base metal industry is presented in the next figure.

Figure 7.1. Structure of the base metal industries (Nace C24) in the EU, based on relative production values, 2005 - 2013



On average, 60% of the EU base metal industry is linked with iron and steel production, 30% with non ferrous metals (i.e. aluminium, copper, etc.), 10% with casting of metals.

Figure 7.2. Value added generated by the base metal industry in the member states of the EU, 1995-2012 average

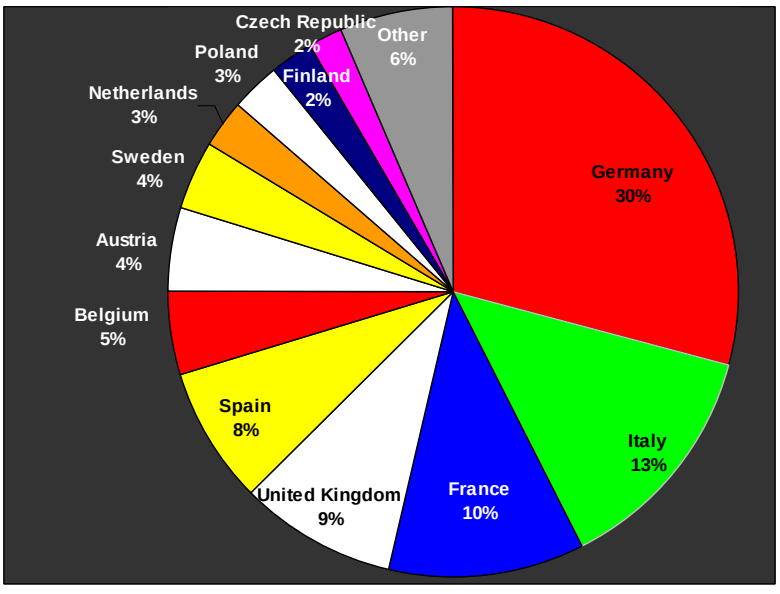


Figure 7.2 shows that 75% of the value added generated by the base metal industry is concentrated in 6 member states, of which 5 large member states and one smaller (Belgium).

Data coverage

For 19 of the 28 member states of the EU, data on environmental expenditures of the base metal sector are available, covering for some years almost 100% of investments and operational costs of this sector in the EU.

Figure 7.3. Approximate coverage of the data on environmental expenditures of the base metal sector (Nace C24) in total in the EU, on basis of value added in member states of the sectors studied and number of member states submitting data, 1995 - 2012

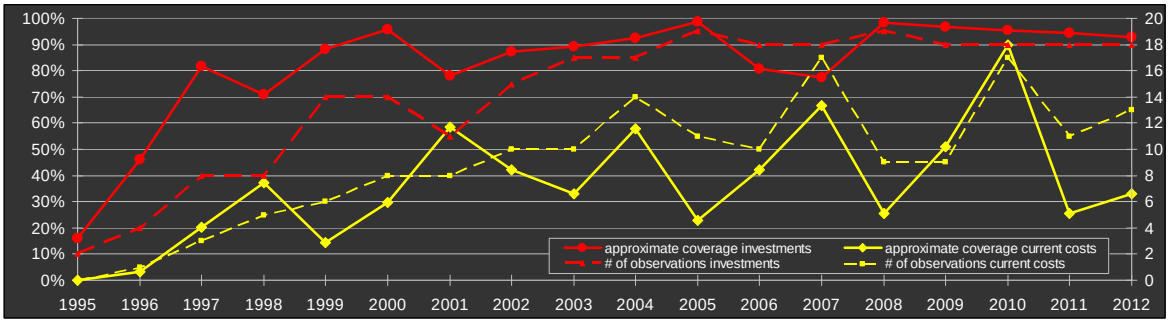


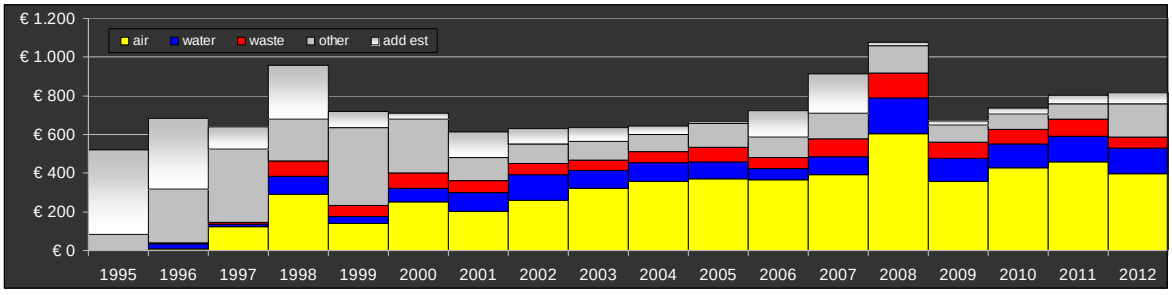
Figure 7.3 shows that for most years, over 80% of the sectoral environmental investments are covered, from 2008 onwards over 90%.

The coverage of operational costs is much lower, only in 1 year – 2010 – more than 80% of EU is covered. For 2001, 2004 and 2007 the coverage is about 60%, for other years as low as 15% to 40%.

Environmental investments of the base metal sector (Nace C24)

As data on absolute environmental investments is incomplete, additional environmental investments are estimated by using the "coverage" percentages, presented in the previous section to arrive at estimated investment totals for the base metal sector in the EU. The resulting estimated absolute environmental investments are presented in figure 7.4.

Figure 7.4. Observed and additional estimated absolute annual environmental investments of the base metal sector (Nace C24) in the EU per environmental domain, in € million per year (current price level), 1995 - 2012



In 2008, the highest environmental investment expenditures of the base metal sector in the EU are observed, with a total of over € 1 billion. Environmental investments peak also in 1998. In most other years, the annual investments range from € 600 million to € 800 million. Investments for "air" are most important, followed by "water" and "other".

There is no clear trend visible in the absolute investments, other than that environmental investments of the base metal sector are relatively stable with "now and then" a peak.

The following figure shows the relative environmental investments, as share of total gross investments of the chemical sector in the EU (average € 12 billion per year).

Figure 7.5. Relative environmental investment expenditures of base metal industries (Nace C24), as share of total sectoral gross investments, 1995 - 2012

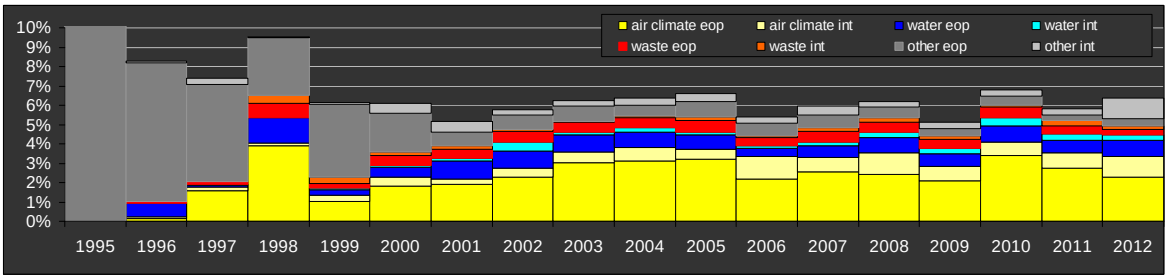


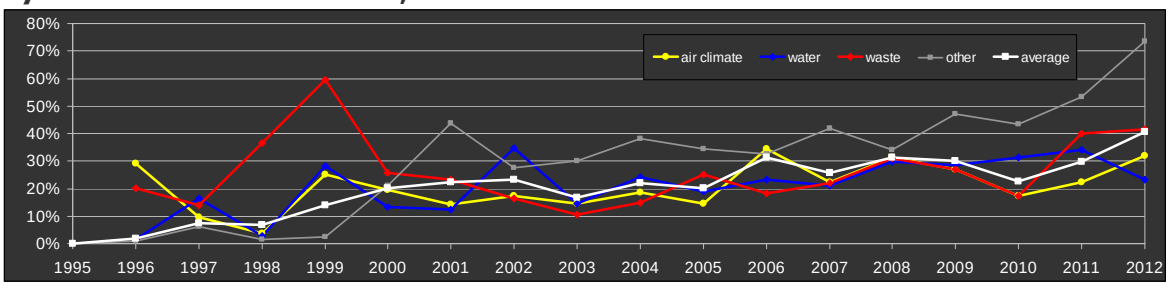
Figure 7.5 shows that the specific environmental investments of the base metal sector are "high" in the period 1995 - 1998 (> 7%), after 2008 they fluctuate between 5% and 7% of sectoral gross investments.

Two types of environmental investments are distinguished:

- End-of-pipe investments, like filters, etc.
- Process integrated investments.

Since 1996 data on integrated environmental investments in the base metal sector are collected by most of the responding countries. In figure 7.6 the results are presented for the base metal sector.

Figure 7.6. Share of integrated environmental investments in total environmental investment expenditures of the base metal sector (Nace C24), by environmental domains, 1995 - 2012



The presented results show that integrated investments become a significant part of total environmental investments. Apparently, the average share of these investments increased in the period 1995 – 2012, from 0% to 40%.

Environmental expenditures of the base metal sector

Data on operational environmental expenditures of the base metal sector are as such, that an absolute representation of the total environmental expenditures (investments and operational) would provide an incomplete picture of these expenditures.

Therefore, total environmental expenditures are compared to the value added of the base metal sector, as well as the physical production of crude steel, for the countries that have submitted data.

The specific expenditures per tonne crude steel are – by definition - an overestimation of the actual specific expenditures per tonne, as the environmental costs of the base sector include more than just those of the steel producing/processing industries. As the share of for example the non-ferrous base metal industries are not specifically known, it is not possible to assess the extent of the overestimation. If the different sub-sectors in the base metal sector have identical environmental cost-structures, the specific costs per tonne crude steel are about 50% lower than the calculations show.

The specific environmental expenditures per € 100 value added generated by the base metal sector are presented in figure 7.7, specific environmental expenditures per tonne crude steel are presented in figure 7.8.

Figure 7.7. Relative environmental expenditures (investment and operational) of the base metal industry (Nace C24), per € 100 value added, 1995 - 2012

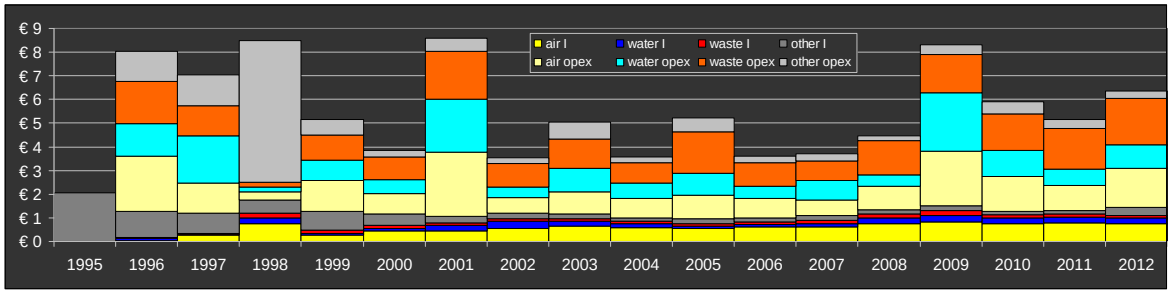
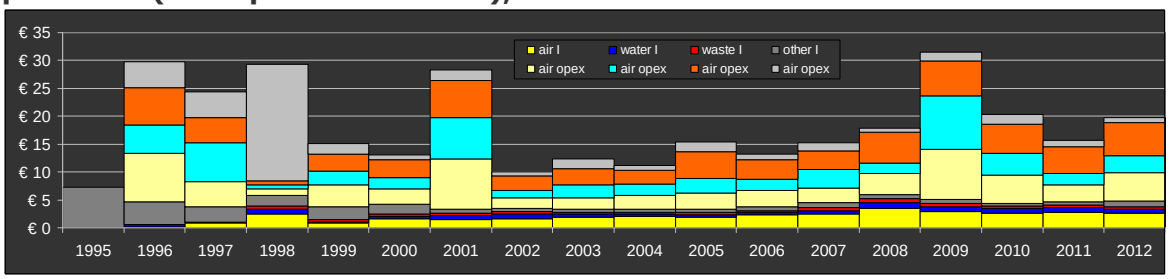


Figure 7.8. Relative environmental expenditures (investment and operational) of base metal industry (Nace C24), per tonne crude steel produced (fixed price level 2012), 1995 - 2012



There are no large differences between the two the ways of calculating the specific expenditures. Both for "per € 100 value added" and "per tonne crude steel" the development of specific expenditures follows the same pattern. In the years 1996 – 2001, expenditures are relative high: up to € 8 per € 100 value added, or € 30 per tonne crude steel. In the period 2002 – 2012, specific environmental expenditures are on average lower: from € 3.5- € 6 per € 100 value added, or from € 10 to € 20 per tonne crude steel.

The specific investments form the smallest part of total specific environmental expenditures: between € 1 and € 2 per € 100 value added or € 5 or less per tonne crude steel.

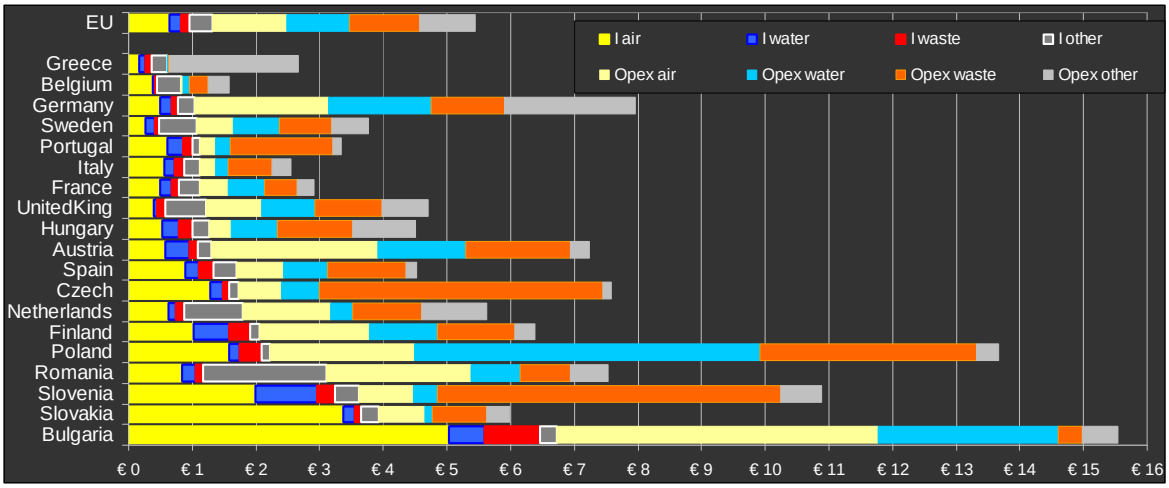
The specific operational environmental expenditures of the base metal sector constitute between 60% to 80% (and higher) of total specific expenditures. The operational environmental expenditures of the base metal sector follow a rather

irregular pattern, with for at least for two years (2001 and 2009) high peaks with (more than) double operational costs than surrounding years. These fluctuations of the specific operational expenditures are probably due to the low coverage of operational expenditures in most years (the absence of most data for larger member states). Operational expenditures in the domains "air", "waste" and "water" are the most important for the base metal sector.

Environmental expenditures in the base metal sector per member state

There is a large variation in the specific environmental expenditures of the base metal sector in member states of the EU as shown in figure 7.9.

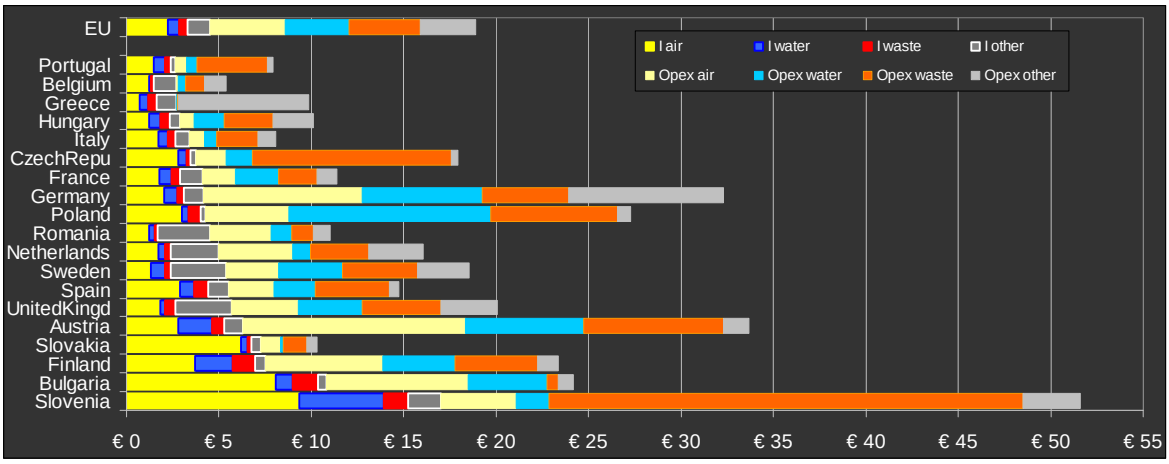
Figure 7.9. Average annual environmental investments (I) and current expenditures (OPEX) of the base metal industry (Nace C24), per € 100 value added, 1995 - 2012



Specific environmental expenditures of the base metal sector range from € 1.60 (Belgium) per € 100 value added to € 15.50 (Bulgaria). The average is € 5.50 per € 100 value added, of which € 1.30 investments and € 4.20 operational expenditures. The largest producer of base metals, Germany, has relatively high expenditures (+50% or more), compared to the EU average and other large producers.

If environmental expenditures of the base metal sector are related to the production of crude steel, some differences appear, as is shown in figure 7.10.

Figure 7.10. Average annual environmental investments (I) and current expenditures (OPEX) of the base metal industry (Nace C24), per tonne crude steel (fixed price level 2012), 1995 - 2012



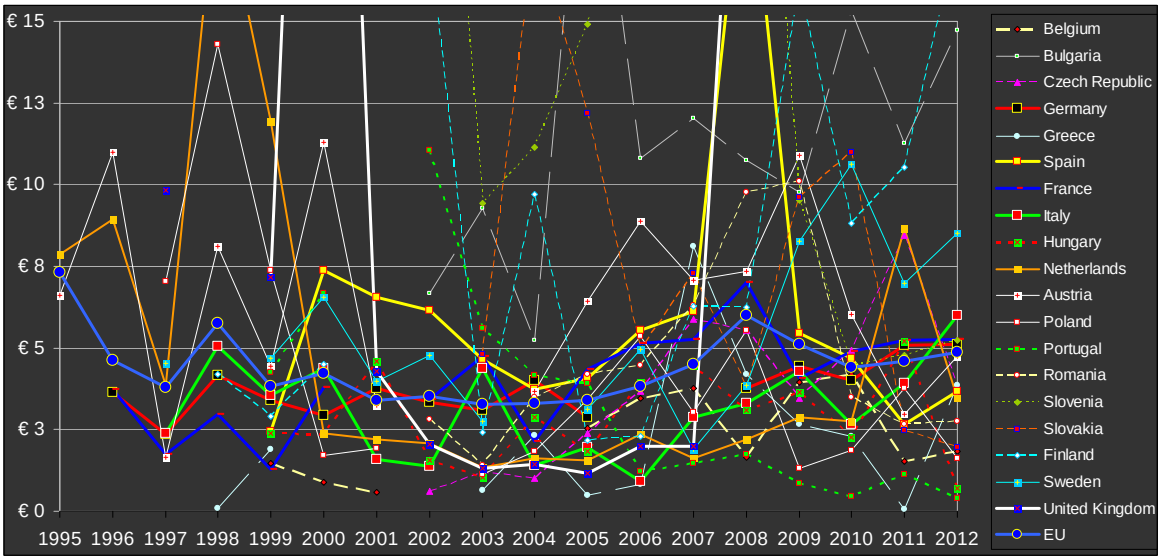
The average specific expenditures per tonne crude steel are € 19, of which about € 5 investments and € 14 operational expenditures. Lowest specific expenditures are recorded in Belgium (€ 5.5 per tonne crude steel), highest in Slovenia (€ 52 per tonne crude steel). Again, the base metal sector in Germany has relative high specific expenditures (€ 32.5 per tonne crude steel).

Of the 6 member states with the largest value added of base metal sector, the base metal sector in Germany has higher than average specific environmental expenditures. The base metal sector in Belgium has the lowest specific expenditures.

Figure 7.11 gives detailed information on the relative environmental investment expenditures of the base metal sector in member states. It shows that the development thereof is very irregular. Years or periods with high levels of environmental investments are followed by years with lower investments.

Although the EU-average shows a somewhat decreasing trend, this trend is not obvious for all member states, especially for newer member states, specific investments are often (much) higher than the EU-average.

Figure 7.11. Relative environmental investments of the base metal industry (Nace C24) in EU member states, per tonne crude steel (fixed price level 2012), 1995 - 2012

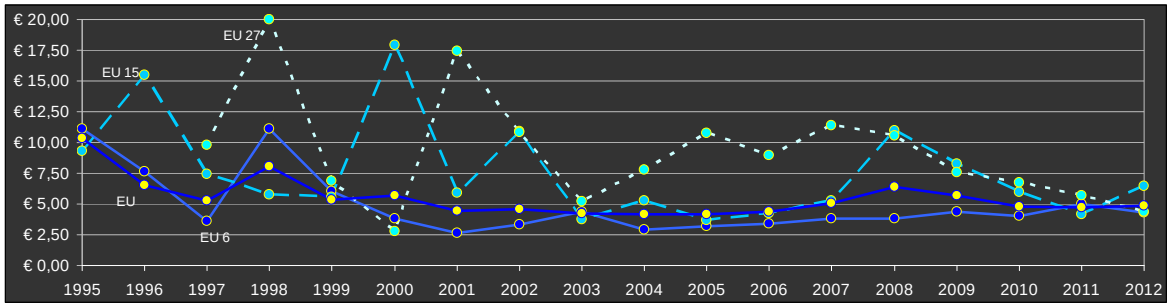


To analyse potential regional differences of the specific environmental investments, the EU member states are grouped in three groups:

- EU 6: Germany, France, Italy, Netherlands, Belgium;
- EU 15: United Kingdom, Spain, Portugal, Greece, Austria, Sweden, Finland;
- EU 27: Poland, Hungary, Czech Republic, Slovakia, Slovenia, Romania, Bulgaria.

This is shown in figure 7.12.

Figure 7.12. Relative environmental investments in the base metal sector in the EU, per tonne crude steel (fixed price level 2012), 1995 - 2012



Specific environmental investments for the base metal sector in the EU are at the end of the period 1995 - 2012 about € 5 per tonne crude steel. This is about the same for the "old" (EU 6), "second wave" (EU 15) and "new" (EU 27) member states. In the beginning of the period (1995 – 2002), specific investments are relatively higher than at the end of the period (2002 -2012). Over the whole period, the specific investments of the base metal sector in "second wave" (EU 15) and "new" (EU 27) member states, are well above the EU average.

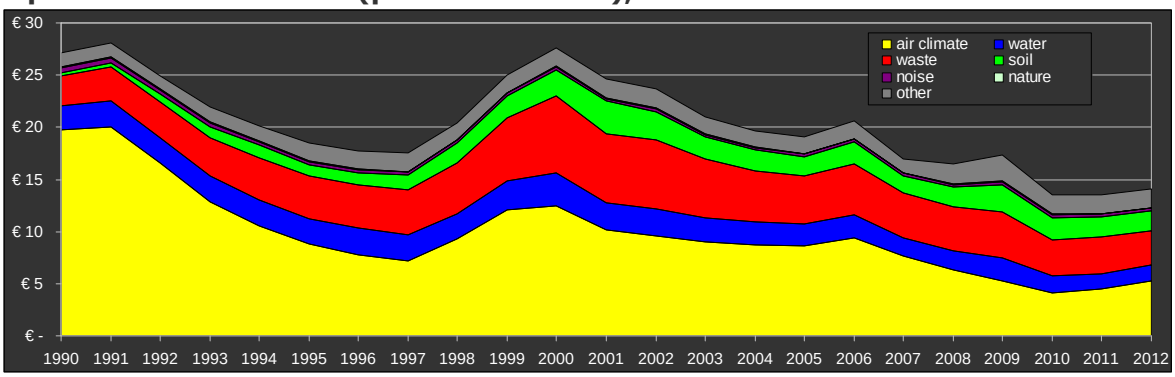
Environmental costs of the base metal sector in the Netherlands

Data on the environmental expenditures of industry in the Netherlands, including the base metal sector (Nace C24), date back to 1979. In this year, the CBS started collecting data on environmental expenditures of manufacturing industries in 1979. For each of the manufacturing sectors, time-series on investments have been collected from 1974 onwards. Also, methods were developed to assess annual current environmental costs.

CBS has developed a way to present annualised environmental expenditures, by calculating capital costs (depreciation and interest) in a standardised way (see chapter on methodology). This enables the presentation and analysis of relative long time-series (22 years).

In the next figure, total environmental costs of the base metal sector in the Netherlands are shown, in relation to the output of crude steel. Costs are expressed in € per tonne crude steel. The price of crude steel has large fluctuations and is currently around € 300 per tonne (Platts, 2015).

Figure 7.13. Annualised environmental expenditures (capital costs and operational costs) of the base metal industry (Nace C24) in the Netherlands, € per tonne crude steel (price level 2012), 1990 - 2012

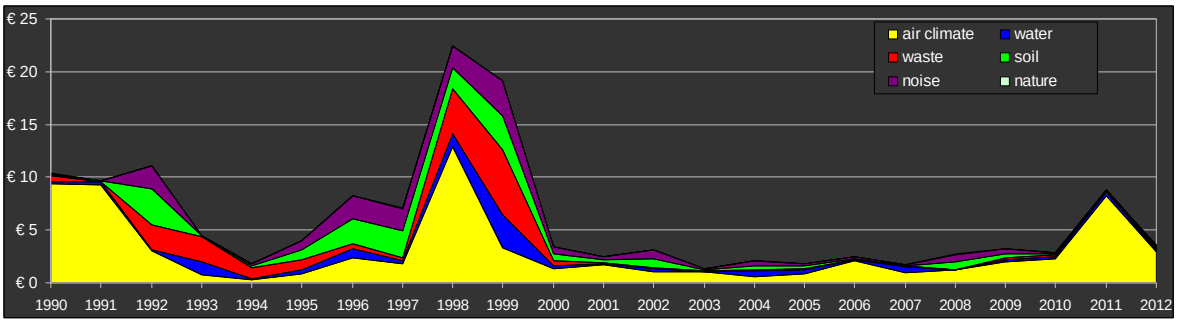


Specific environmental costs for the base metal sector in the Netherlands start in the early 90-ties at € 27 per tonne steel. By 1997 the specific costs have lowered € 10 per tonne steel. Due larger investments that start in 1996 the specific costs increase between 1997 and 2000 with € 10. After 2000 a downward trend of the specific costs is apparent: costs drop by (almost) € 15 per tonne steel, which leads to specific environmental costs for the base metal sector in the Netherlands of € 13.5 per tonne crude steel in 2012.

The development of investments and operational costs, which form the basis for the calculation of total environmental costs for the base metal sector, is shown in the next two figures.

The specific environmental investments of the base metal sector in the Netherlands show three periods with higher investments (> € 5 per tonne steel): 1990-1993; 1996-1999 and 2011. This is shown in the next figure.

Figure 7.14. Annual environmental investments of the base metal industries (Nace C24) in the Netherlands, € per tonne crude steel (price level 2012), 1990 - 2012

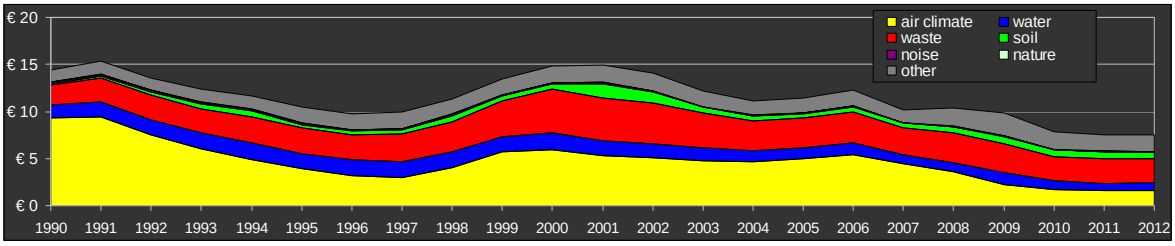


As the environmental investments between 1990 and 1993 partly replace earlier capital investments (from the 80-ties), these have hardly an effect of the total specific costs, actually, depreciation and interest costs drop by € 5 per tonne until 1997. The large investments in 1998 and 1999, bring the total specific costs back to the level of the beginning of the 90-ties. The low investment level from 2000 onwards, causes a drop of about € 6 of the total specific costs in the period 2000 – 2012.

The next figure shows that the development of the specific operational environmental costs is largely influenced by investments. A period of high environmental investments

increases the operational costs, but these tend to decrease afterwards, until a new large investment is made.

Figure 7.15. Annual operational environmental costs of the base metal industries (Nace C24) in the Netherlands, € per tonne crude steel (price level 2012), 1990 - 2012



From 1991 to 1996, specific operational costs drop 35%, from 2000 till 2012 they drop about 50%.

There are various possible explanations for the development of the specific environmental costs of the base metal sector in the Netherlands:

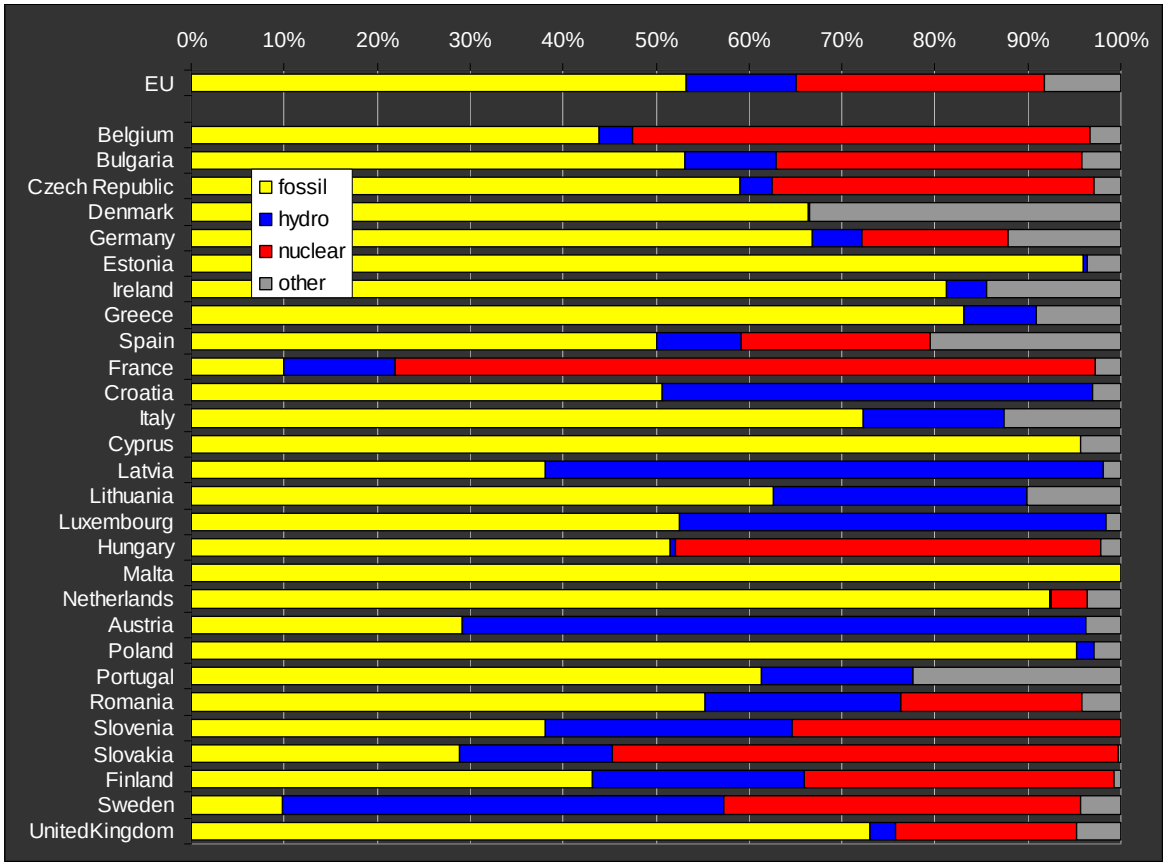
- (periods with) high levels of investment, due to implementation of higher environmental standards;
- due to technological progress and innovations, specific investment costs tend to decrease in general. There are also indications that this process goes faster for environmental technologies. The specific investments in the period before 2000 are considerably higher than after 2000!
- the increasing share of "process integrated" environmental technologies, which decrease investment costs;
- automation, which has affected operations in all economic sectors: less personnel, more efficient use of resources, etc.

Power sector

The power sector (Nace D35) in the EU is essential to all other industrial sectors and households in the EU. Annually, the power sector produces about 3 billion MWh electricity (average), in 2012 3.2 billion MWh. This generates annually on average € 168 billion value added for the power sector, in 2012 even € 232 billion. About 25% of all environmental expenditures of the sectors studied (Nace B, C and D) are in the power sector.

The structure of the power sector – by type of resources used to generate electricity - in the EU member states varies largely, as shown in figure 8.1.

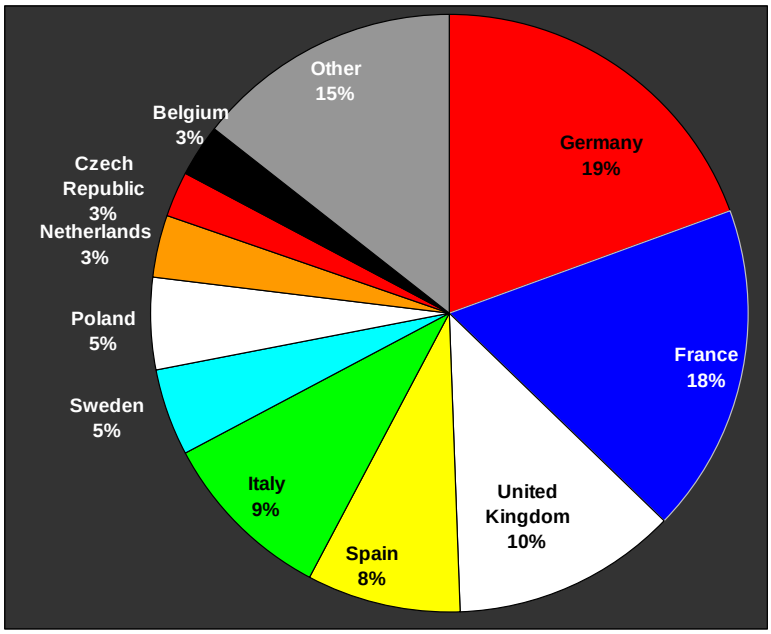
Figure 8.1. Structure of the power sector (NaceD35) in member states of the EU, by type of resource (fossil, hydro, nuclear, other), average power generation in GWh, 2012



In some member states, almost exclusively fossil fuels are used to generate electricity (Estonia, Ireland, Greece, Cyprus, Malta, the Netherlands, Poland). In other member states nuclear power plays an important role (France, Belgium, Bulgaria, Czech Republic, Slovakia, Slovenia, Hungary, Finland, Sweden). Hydro power is also important for electricity generation in a few member states (Austria, Sweden, Luxemburg, Latvia, Croatia). Other sources for electricity generation (mainly "renewable") do not yet contribute much (less than 10%) to overall power generation in the EU. Member states with relative high share of "renewables" are Denmark, Spain, Italy, Germany, Portugal, Ireland.

Overall, still over 50% of electricity in the EU is generated from fossil fuels. Nuclear power covers almost 30% of electricity generation, hydro power a little more than10% and renewables almost 10%.

Figure 8.2. Electricity generation per member state in the EU, average 1995 - 2012



Seven member states are responsible for over 75% of the electricity generated in the EU. Remarkably, one small member state (Sweden) is amongst these 7 largest producers, even before Poland.

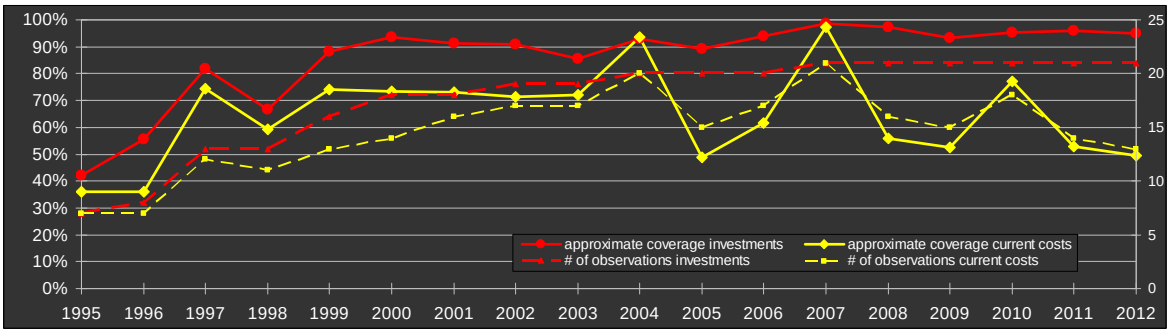
As can be expected, Germany, France and the United Kingdom are the largest electricity producers, covering 50% of total production.

Data coverage

In total, 21 member states collect and submit data on the environmental expenditures of the power sector for several years of the period 1995 - 2012. In the early years of this period (until 2000), data of 9 to 16 member states submitted data. After 2000, coverage gets gradually higher.

For investments, this leads to a coverage of (almost) 90% or higher from 1999 onwards. The coverage of operational environmental expenditures is lower, leading to an overall coverage of about 70%, with peaks in 2004, 2007 and 2008.Thisis shown in figure 8.3.

Figure 8.3. Approximate coverage of the data on environmental expenditures of the power sector (Nace D35) in total in the EU, on basis of value added in member states of the sectors studied and number of member states submitting data, 1995 - 2012

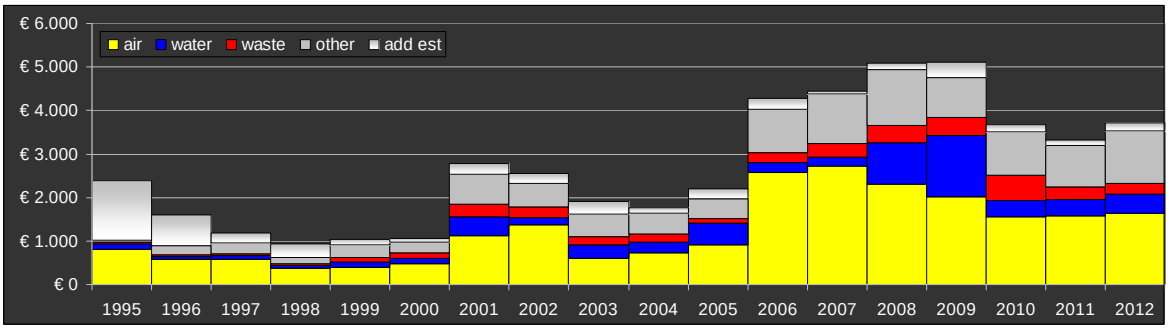


Data on the gross electricity generation of the power sector are derived from Eurostat energy statistics (Eurostat, 2015). Whereas the structural business statistics subdivide data by Nace sector, in the energy statistics of Eurostat it is not 100% clear what kinds of electricity production should be included, to arrive at optimal correspondence with data on environmental expenditures from the structural business statistics. A potential overestimation of electricity production will be systematic (for all member states the same type of error) it can be anticipated that the overall error will be relatively small.

Environmental investments of the power sector (Nace D35)

To arrive at estimated investment totals for the power sector in the EU, and data on absolute environmental investments is incomplete, additional environmental investments are estimated by using the "coverage" percentages, presented in the previous section. The resulting estimated absolute environmental investments are presented in figure 8.4.

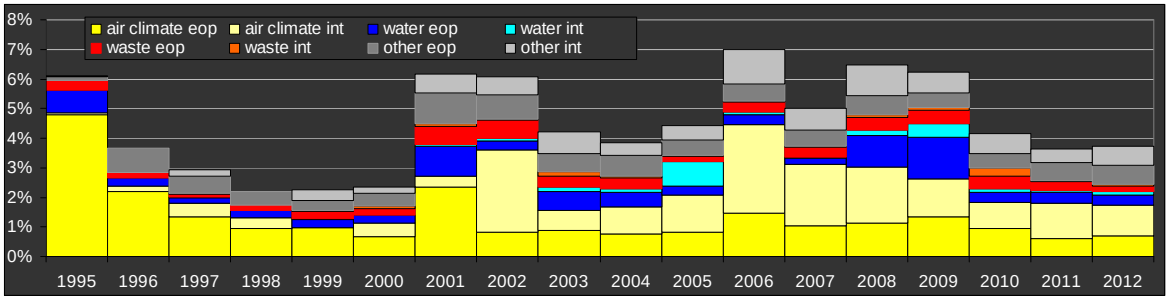
Figure 8.4. Observed and additional estimated absolute annual environmental investments of the power sector (Nace D35) in the EU per environmental domain, in € million per year (current price level), 1995 - 2012



The period 1995 – 2012 can be subdivided in 4 sub-periods. From 1995 till 2000, environmental investments drop from € 2.4 billion to around € 1 billion. The period 2001 – 2005 starts with high investments of € 2.8 billion dropping to around € 2 billion at the end. The third period, 2006 – 2009, is one with high investments (> € 4 - € 5 billion). The last 3 years, investments are still high, but at a level of about € 3.5 billion. In general, there is an upward trend over the whole period.

The following figure shows the relative environmental investments, as share of total gross investments of the power sector in the EU (average € 62 billion per year, 2012 € 100 billion).

Figure 8.5. Relative environmental investment expenditures of the power sector (Nace D35), as share of total sectoral gross investments, 1995 - 2012



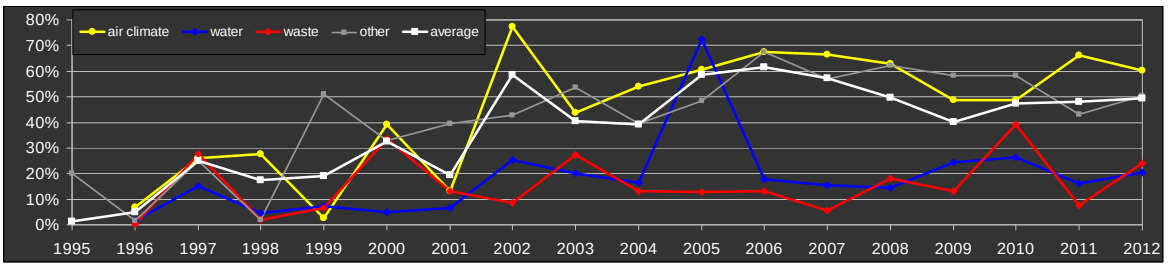
Environmental investments constitute between 2% and 7% of total gross investments of the power sector in the EU. In 6 years (1995, 2001, 2002, 2006, 2008, 2009) investments are "high" at between 6% and 7%. In the other years the environmental investments are relatively low, at between 2% and 5%. Over the whole period, relative environmental investments are higher in the second part (2001 onwards), than in the early years.

Two types of environmental investments are distinguished:

- End-of-pipe investments, like filters, etc.
- Process integrated investments.

Since 1997 data on integrated environmental investments are collected by most of the responding countries. Data for the power sector are shown in the following figure.

Figure 8.6. Share of integrated environmental investments in total environmental investment expenditures of the power sector (Nace D35) in the EU, by environmental domains, 1995 - 2012



The presented results show, that integrated investments form a significant part of total environmental investments. The share of integrated investments increased in the period 1995 – 2012, from about 0% to 50%. Some years, the average peaks at 60% (2006), for "air" even at 75% (2002). The share of integrated investments for "water" and "waste" is in general below average.

Environmental expenditures of the power sector

The coverage of data on operational environmental expenditures of power sector is such, that an absolute representation of the total environmental expenditures (investments and operational) provides an incomplete picture of these expenditures.

Therefore, total environmental expenditures are compared to the value added of the power sector, as well as the generation of electricity, for the countries that have submitted data. Even in this way the results for operational expenditures may be biased for years with low data coverage, because data for one or more larger member states missing may affect the specific expenditures (average for EU) considerably.

The specific environmental expenditures per € 100 value added generated by the power sector are presented in figure 8.7, specific environmental expenditures per MWh electricity generated are presented in figure 8.8.

Figure 8.7. Relative environmental expenditures (investment and operational) of the power sector (Nace D35), per € 100 value added, 1995 - 2012

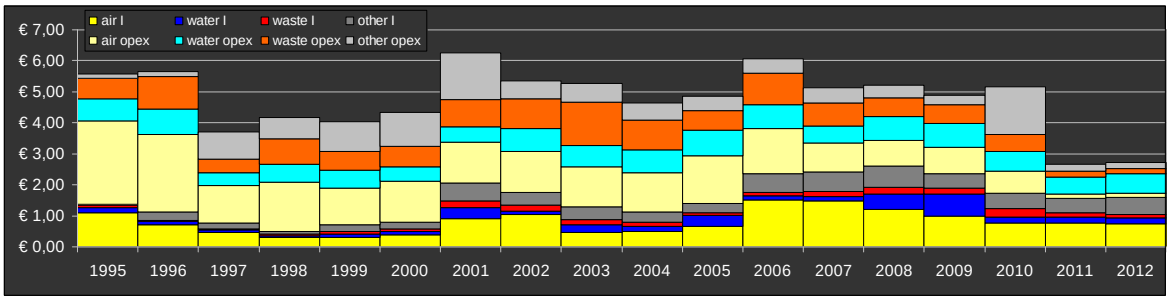
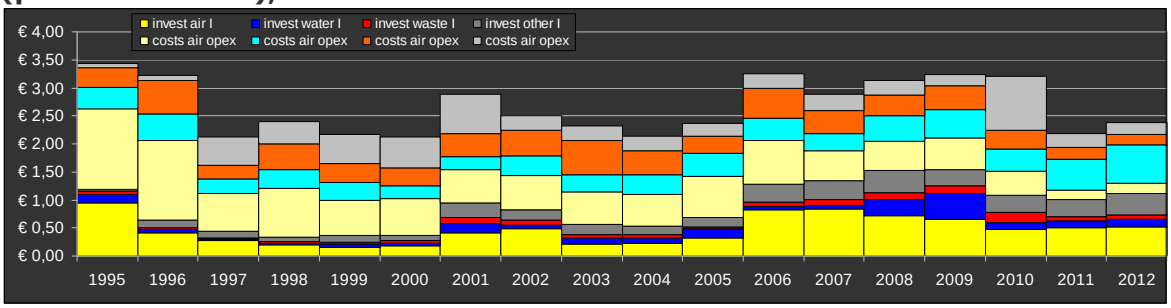


Figure 8.8. Relative environmental expenditures (investment and operational) of the power sector (Nace D35), per MWh electricity produced (price level 2012), 1995 - 2012



Although there are some slight differences between the both approaches to estimate relative environmental expenditures, the general trends are the same.

If specific expenditures are expressed per € 100 value added, in most years of the period, these vary between € 4 and € 6. Only in 2011 and 2012, specific expenditures drop to under € 3 per € 100 value added. Compared to MWh´s generated by the power sector, specific expenditures fluctuate between € 2 and € 3.5 per MWh.

In both approaches, relative high specific expenditures occur in 1995-1996, 2001, 2006-2010.

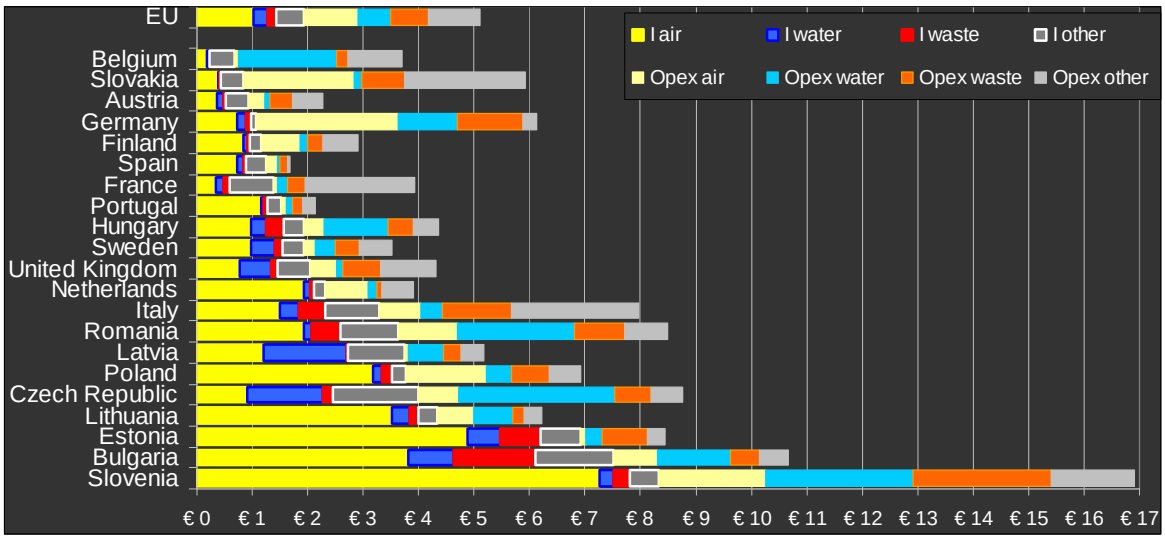
Operational expenditures form in the years until 2005, the largest part of the specific environmental expenditures of the power sector. After 2005, operational and investment expenditures are more or less balanced. This may indicate a shift in the type of environmental investments of the power sector: from "fossil" to "renewable".

It is remarkable that the large share in operational expenditures for "air", drops considerably during the period 1995 -2012. Operational environmental expenditures for "water" increase during the second half of the period.

Environmental expenditures in the power sector per member state

Figure 8.9 shows that there is a large variation in observed environmental expenditures for the power sector in the member states of the EU. Expressed per € 100 value added, specific environmental expenditures are on average € 5, with a lowest value of € 1.7 (Spain) and a highest value of almost € 17 (Slovenia).

Figure 8.9. Average annual environmental investments (I) and current expenditures (OPEX) of the power sector (Nace D35), per € 100 value added, 1995 - 2012

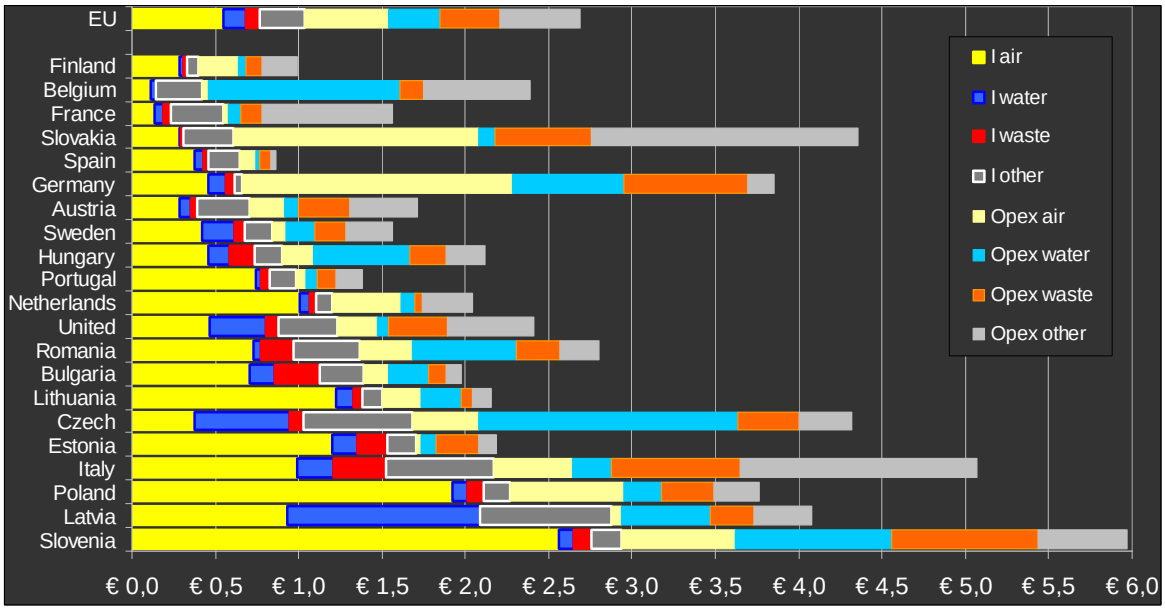


Relative high levels of specific operational expenditures (> € 5) are observed for the power sectors of Germany, Slovakia, Italy, Romania, Czech Republic and Slovenia. In most other member states these expenditures are (much) lower than the EU average.

Almost all "new" member states have higher than average specific investments and operational costs.

The next figure 8.10 shows the average specific environmental expenditures of the power sector in € per MWh.

Figure 8.10. Average annual environmental investments (I) and current expenditures (OPEX) of the power sector (Nace D35), per MWh produced, 1995 - 2012



Average specific environmental expenditures are € 2.7 per MWh (investments € 1, operational € 1.7), with a lowest value of € 0.8 (Spain) and a highest value of € 6 per

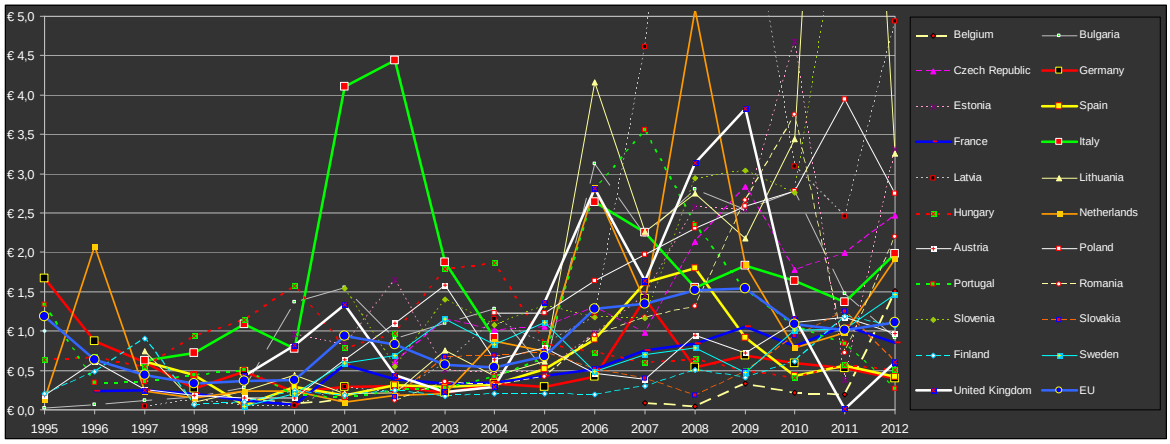
MWh (Slovenia). Again, in some member states the level of the specific operational expenditures is remarkably high compared to the other member states: Germany, Slovakia, Czech Republic, Italy, Slovenia.

Almost in all "new" member states the specific environmental investments are higher than the EU average.

Figure 8.11 gives detailed information on the relative environmental investment expenditures of the power sector in member states. It shows that the development thereof is very irregular. Years or periods with high levels of environmental investments are followed by years with lower investments.

The scatter plot presented in figure 8.11, shows that the specific environmental investments are higher in the second part of the period than in the earlier years.

Figure 8.11. Relative environmental investments of the power sector (Nace D35) in EU member states, per € 100 value added, 1995 - 2012

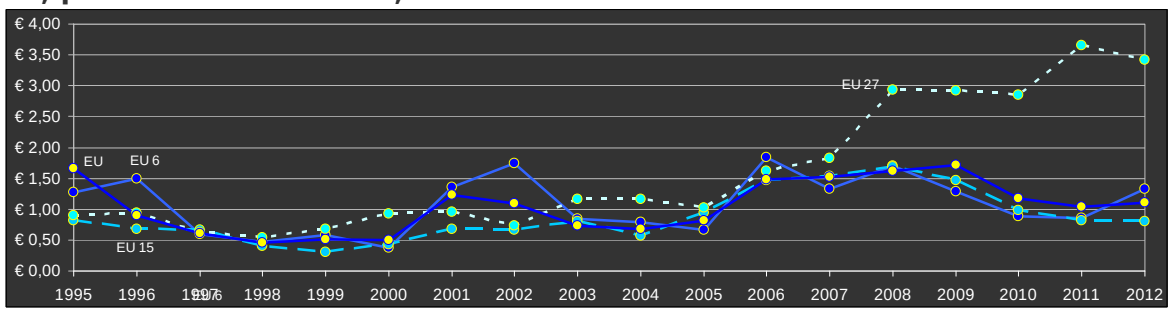


To analyse potential regional differences in trends of the specific environmental investments, the EU member states are grouped in three groups:

- EU 6: Germany, France, Italy, Netherlands, Belgium;
- EU 15: United Kingdom, Spain, Portugal, Greece, Austria, Sweden, Finland;
- EU 27: Poland, Hungary, Czech Republic, Slovakia, Slovenia, Romania, Bulgaria.

In figure 8.12 the result of this analysis are presented.

Figure 8.12. Relative environmental investments in the power sector in the EU, per € 100 value added, 1995 - 2012



In the period 1995 -2007, for most years, the specific environmental investments for the power sector in the EU, and EU 6/15/27, fluctuate between € 0.5 an € 1.75 per €

100 value added of the sector. After 2007, specific investments of the power sector in "new" member states (EU 27) increase to € 3 to € 3.5 per € 100 value added. For the other groups "EU", "old" (EU 6), "second wave" (EU 15) the specific investments remain at lower levels of between € 0.8 and € 1.75.

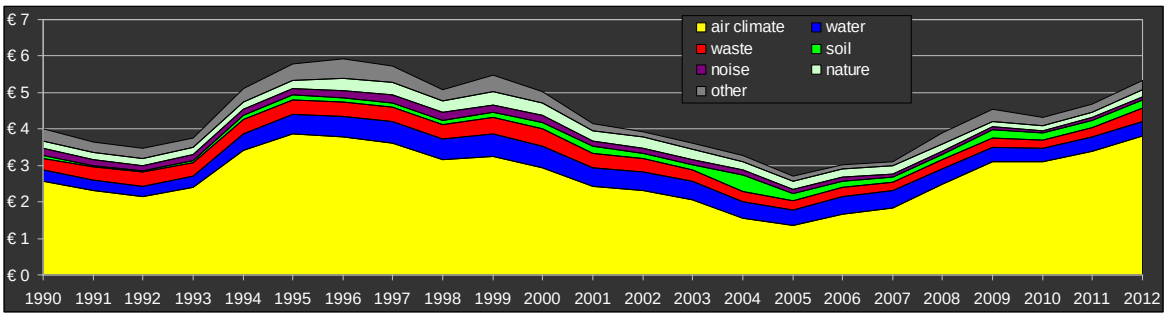
Environmental costs of the power sector in the Netherlands

Data on the environmental expenditures of industry in the Netherlands, including the power sector (Nace D35), dates back to 1979. In this year, the CBS started collecting data on environmental expenditures of manufacturing industries in 1979. For each of the manufacturing sectors, time-series on investments have been collected from 1974 onwards. Also, methods were developed to assess annual current environmental costs.

CBS has developed a way to present annualised environmental expenditures, by calculating capital costs (depreciation and interest) in a standardised way (see chapter on methodology). This enables the presentation and analysis of relative long time-series (22 years).

In the next figure, total environmental costs of power sector in the Netherlands are shown, in relation to electricity produced. Costs are expressed in € per MWh. The production costs of 1 MWh are about € 40 per MWh in the Netherlands.

Figure 8.13. Annualised environmental expenditures (capital costs and operational costs) of the power sector (Nace D35) in the Netherlands, € per MWh (price level 2012), 1990 - 2012

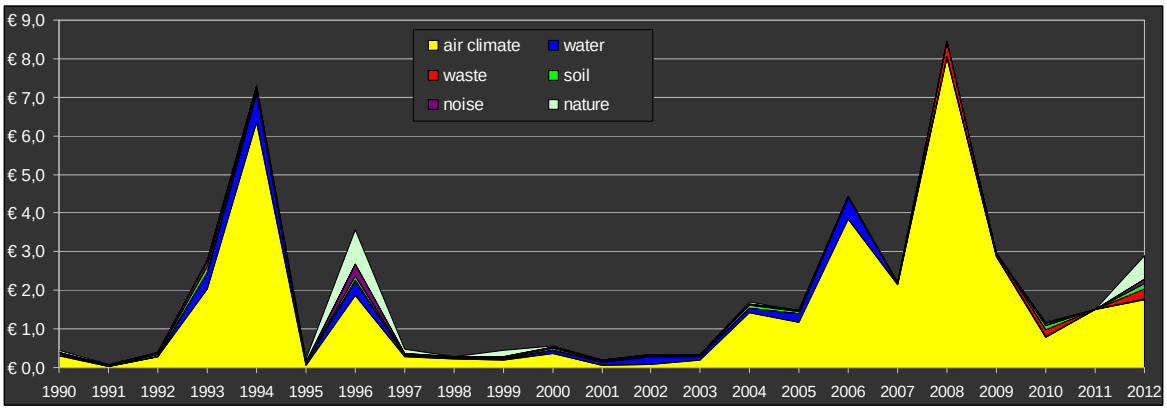


The specific environmental costs for the power sector in the Netherlands fluctuate: they increase from € 4 per MWh in 1990 to € 6 in 1996, and then fall back to € 2.5 in 2005 and next rise again to € 5.3 in 2012.

The development of investments and operational costs, which form the basis for the calculation of total environmental costs for the power sector, is shown in the next two figures.

The specific environmental investments of the power sector in the Netherlands show various investment peaks: 1993, 1994, 1996 and the whole period 2004 – 2012. In between, the specific environmental investments are lower than € 1 per MWh in 11 of the 22 year time span of the period analysed. This is shown in figure 8.14.

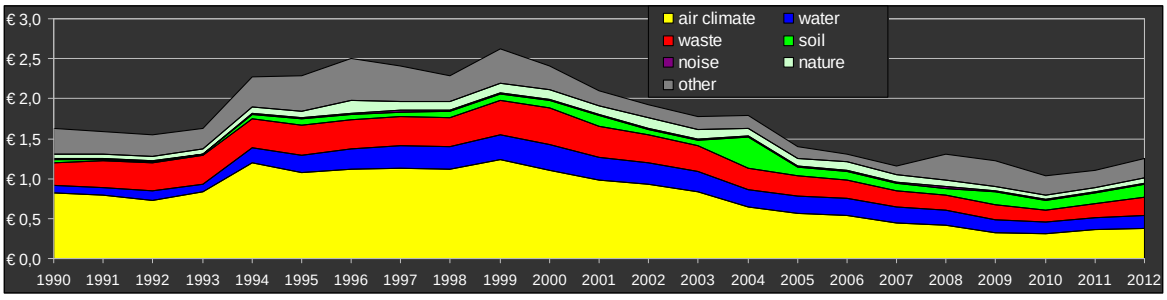
Figure 8.14. Annual environmental investments of the power sector (Nace D35) in the Netherlands, € per MWh (price level 2012), 1990 - 2012



The investment peak in the mid 90-ties, pushes the annualised specific environmental costs up (from € 3.5 to € 6 per MWh), due to increased costs of depreciation and interest. Lower specific investments in the period 1997 – 2004 lead to a gradual decrease of costs of depreciation and interest. The higher level of specific investments from 2004 onwards, pushes up the specific environmental costs after 2004 from € 2.5 in 2005 to € 5.2 per MWh in 2012.

The next figure shows the development of the specific operational environmental costs of the power sector in the Netherlands. From 1990 to 1999, the specific costs increase from € 1.5 to € 2.5 per MWh. After 2000, the specific operational costs gradually decrease by 50% to around € 1.25 per MWh in the period 2007 – 2012.

Figure 8.15. Annual operational environmental costs power sector (Nace D35) in the Netherlands, € per MWh (price level 2012), 1990 - 2012



To what extent the lower level of specific operational environmental costs after 2007 is "permanent" is difficult to say. The structure of the power sector in the Netherlands is changing due to concerns about climate change. Large investments are planned for off-shore wind, and it is not clear how this will affect specific operational costs. Unfortunately, until recent, environmental costs in the "air" domain included as well controlling air-pollution (SO2, NOX, PM10, etc.) as "climate change" investments, without further specification. Since 2012, CBS makes a distinction between "air-pollution" and "climate change", but due to confidentiality of data, no information is (yet) available.

If the development of the specific operational costs is compared to the development of total specific costs, it can be concluded that the development of the latter is partly due to the development of specific operational costs, but also strongly depends on the level of investments. Where in other sectors the operational costs dominate total

costs, for the power sector this is different. Costs of depreciation make up between 45% (in 2004) to 75% (after 2009)of total specific costs.

There are various possible explanations for the development of the specific environmental costs of the power sector in the Netherlands:

- (periods with) high levels of investment, due to implementation of higher environmental standards (90-ties);
- investments in renewable energy (wind, after 2004);
- automation, which has affected operations in all economic sectors: less personnel, more efficient use of resources, etc.

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Annex 1: Nace rev. 1/1.1/2, correspondence table

NACE rev 1: 1995-2001		NACE rev 1.1: 2001-2007		NACE rev 2.: 2008-2012	
C	Mining and quarrying	C	Mining and quarrying	B	Mining and quarrying
		CA	Mining and quarrying of energy producing materials		
		CA10	Mining of coal and lignite; extraction of peat	B05	Mining of coal and lignite
		CA11	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying	B06	Extraction of crude petroleum and natural gas
		CA12	Mining of uranium and thorium ores		
		CB	Mining and quarrying except of energy producing materials		
		CB13	Mining of metal ores	B07	Mining of metal ores
		CB14	Other mining and quarrying	B08	Other mining and quarrying
				B09	Mining support service activities
		D	Manufacturing	C	Manufacturing
DA	Manufacture of food products, beverages and tobacco	DA	Manufacture of food products, beverages and tobacco	C10	Manufacture of food products
		DA15	Manufacture of food products and beverages	C11	Manufacture of beverages
		DA16	Manufacture of tobacco products	C12	Manufacture of tobacco products
DB_DC	Manufacture of textiles and textile products; leather and leather products	DB	Manufacture of textiles and textile products	C13	Manufacture of textiles
		DB17	Manufacture of textiles	C14	Manufacture of wearing apparel
		DB18	Manufacture of wearing apparel; dressing; dyeing of fur		
		DC	Manufacture of leather and leather products	C15	Manufacture of leather and related products
DD	Manufacture of wood and wood products	DD	Manufacture of wood and wood products	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
DE	Manufacture of pulp, paper and paper products; publishing and	DE	Manufacture of pulp, paper and paper products; publishing and printing	C17	Manufacture of paper and paper products
		DE21	Manufacture of pulp, paper and paper products		
		DE22	Publishing, printing and reproduction of recorded media	C18	Printing and reproduction of recorded media
DF	Manufacture of coke, refined petroleum products and nuclear fuel	DF	Manufacture of coke, refined petroleum products and nuclear fuel	C19	Manufacture of coke and refined petroleum products
DG_DH	Manufacture of chemicals; rubber and plastic products	DG	Manufacture of chemicals, chemical products and man-made fibres	C20	Manufacture of chemicals and chemical products
		DH	Manufacture of rubber and plastic products	C22	Manufacture of rubber and plastic products
				C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
DI	Manufacture of other non-metallic mineral products	DI	Manufacture of other non-metallic mineral products	C23	Manufacture of other non-metallic mineral products
DJ_DN36	Manufacture of basic metals and fabricated metal products; furniture and manufacturing n.e.c.	DJ	Manufacture of basic metals and fabricated metal products		
DJ27	Manufacture of basic metals	DJ27	Manufacture of basic metals	C24	Manufacture of basic metals
		DJ28	Manufacture of fabricated metal products, except machinery and equipment	C25	Manufacture of fabricated metal products, except machinery and equipment
		DK	Manufacture of machinery and equipment n.e.c.	C28	Manufacture of machinery and equipment n.e.c.
		DL	Manufacture of electrical and optical equipment	C26	Manufacture of computer, electronic and optical products
		DL30	Manufacture of office machinery and computers		
		DL31	Manufacture of electrical machinery and apparatus n.e.c.	C27	Manufacture of electrical equipment
		DL32	Manufacture of radio, television and communication equipment and apparatus		
		DL33	Manufacture of medical, precision and optical instruments, watches and clocks		
		DM	Manufacture of transport equipment		
		DM34	Manufacture of motor vehicles, trailers and semi-trailers	C29	Manufacture of motor vehicles, trailers and semi-trailers
		DM35	Manufacture of other transport equipment	C30	Manufacture of other transport equipment
		DN	Manufacturing n.e.c.		
		DN36	Manufacture of furniture; manufacturing n.e.c.	C31	Manufacture of furniture
				C32	Other manufacturing
				C33	Repair and installation of machinery and equipment
E40	Electricity, gas, steam and hot water supply	E	Electricity, gas and water supply	D	Electricity, gas, steam and air conditioning supply
		E40	Electricity, gas, steam and hot water supply	D35	Electricity, gas, steam and air conditioning supply
E41	Collection, purification and distribution of water	E41	Collection, purification and distribution of water	E36	Water collection, treatment and supply