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Value of decomposition figures in emission reduction policy analysis at international level.

Report of a traineeship at RIVM

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Abstract

Decomposition analysis is a method for disentangling the different key-factors that determine temporal changes in emission levels. It is a 'top-down' method starting from general available statistical data. This report explores the role decomposition diagrams can play in national and international policy analysis and evaluation. For this purpose a case study has been performed. The case study concerns the reduction of NO_x-emissions from combustion plants in industries in the Netherlands and Belgium in the 1985-1999 period. NO_x-emission reduction policies have been studied and linked with the effect of NO_x-emission abatement i.e. the technique effect in the decomposition analysis. Policy instrument characteristics have been used to describe the likely effect of studied instruments.

The case study shows that observed changes in the NO_x-technique effect in the Netherlands could be closely linked to specific policy events, such as the introduction and stepwise further improvement of the Dutch Decree on emission limits for large combustion plants (BEES). Hardly any technique effect was observed in Belgium in the period 1985-1999. On the condition that monitoring results of Belgium are reliable, this implies that no clear technical improvement in emission abatement of NO_x has occurred in this period in industrial combustion plants in Belgium. This may be explained by the less ambitious emission regulation in Belgium.

One of the most important conclusions of the case study is that decomposition analysis can play an important role in policy analysis. On the one hand, decomposition figures may confirm expected changes in emissions, and in doing so, underpin the results of detailed policy analysis studies. On the other hand, changes observed in decomposition figures may indicate changes in policies, and in doing so, direct policy analysis studies.

Finally, it may be concluded from the case study that the use of decomposition figures alone already gives a fair idea about the overall effectiveness of NO_x-emission reduction policies in different countries. A broad-based and in-depth study as performed in this study produces more detailed knowledge but also requires much more effort. This time-consuming aspect has to be taken into account when considering and planning these kind of studies.

Preface

This report represents the final product of my work placement at the Laboratory for Waste Materials and Emissions (LAE) at the National Institute for Public Health and the Environment (RIVM). I am grateful to the following organisations for providing much of the information needed, in particular, Statistics Netherlands (CBS), the Flemish Environment Agency (VMM), the Environment Inspection Department of AMINAL (Flanders) and the Economic Commission for Europe of the United Nations (UN-ECE). I would also like to thank the LAE staff members for their help, with special thanks to Winand Smeets and Annemarth Idenburg. I would like to thank Annemarth Idenburg, my supervisor, for thinking several difficulties through with me. Finally, my thanks go to Hans Waardenburg, Department of Science, Technology and Society of the University of Utrecht, for his support.

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Samenvatting

In dit rapport zijn relaties gelegd tussen emissiereductiebeleid en afpelplaatjes om op deze manier een indicatie te geven van de invloed van beleid op het emissieverloop. Daarnaast is de waarde van het gebruik van afpelplaatjes bij internationale beleidsanalyses bepaald. Inzicht in effecten van binnenlands en buitenlands beleid maakt de vergelijking van nationale inspanningen op het gebied van emissiereductie mogelijk, waardoor landen aangesproken kunnen worden op hun gedrag.

De onderzoeksvragen zijn geprobeerd te beantwoorden met behulp van een case study. De case study behandelt de reductie van NOx-emissies afkomstig van stookinstallaties in de industrie van Nederland en België in de periode 1985-1999. In de case study is NO_x-emissiereductiebeleid gekoppeld aan de determinant 'techniekeffect'. De interactie tussen de ontwikkeling van afpelplaatjes en de beschrijving van beleid heeft ertoe geleid dat er koppelingen gevonden zijn tussen beleid en techniekeffect. Daarnaast hebben de instrumentkenmerken ontwikkeld door Van Wijk *et al.* (2001) structuur geboden bij de bepaling van de effecten van de verschillende instrumenten. De instrumentkenmerken 'dwingendheid', 'ambitieniveau', 'toepassingsbereik' en 'uitvoering- en handhavingniveau' zijn toegepast in de case study. Uiteindelijk zijn de gevonden koppelingen van Nederland en België gebruikt voor de vergelijking van het beleid van de twee landen.

Op het RIVM waren afpelplaatjes reeds ontwikkeld voor de doelgroep industrie. In deze afpelplaatjes worden naast het werkelijke emissieverloop de onderliggende ontwikkelingen weergegeven. Het emissieverloop wordt bepaald door verschillende determinanten waaronder schaaleffect, structuureffect, energie-intensiteit-effect, brandstofmixeffect en techniekeffect. De afpelplaatjes zijn tijdens het onderzoek aangepast ten behoeve van de beleidsanalyse. Ten eerste zijn voor elk jaar in de periode 1985-1999 emissies berekend in plaats van om de vijf jaar. Deze mate van detail maakte het mogelijk relaties te leggen tussen beleid en techniekeffect. Ten tweede is de periode van de bestaande afpelplaatjes verlengd door de emissies te berekenen tot 1999, omdat dit tot meer koppelingen tussen beleid en afpelplaatje zou kunnen leiden. Tegelijkertijd met de ontwikkeling van de afpelplaatjes is het beleid van Nederland en België beschreven. Eerst zijn de internationale afspraken beschreven die vastgelegd zijn in de conferentie voor grensoverschrijdende emissies (CLRTAP) (1979) en het Sophia Protocol (1988). Hierna zijn de EU-richtlijn van 1984 en 1988 behandeld die gericht zijn op reductie van emissies door grote verbrandingsinstallaties. Na een beeld te hebben verkregen van het internationale beleidskader van Nederland en België, wordt het nationale beleid beschreven. De beleidsplannen worden beschreven en er wordt ingegaan op de beleidsinstrumenten, omdat instrumenten een belangrijke plaats innemen in de koppeling van beleid aan afpelplaatjes. Speciale aandacht is besteed aan de juridische instrumenten, omdat verwacht werd dat deze instrumenten een grote invloed hebben op het emissieverloop.

Voor het Nederlandse beleid zijn enkele koppelingen gevonden met techniekeffect. Deze koppelingen zijn gevonden tussen het juridische instrument Besluit Emissie-Eisen Stookinstallaties (BEES) en techniekeffect. In België heeft techniekeffect zich nauwelijks ontwikkeld, waardoor relaties moeilijk te leggen waren. De afwezigheid van techniekeffect wordt verklaard door de makkelijk haalbare emissie-eisen in België. De koppelingen tussen beleid en afpelplaatje van Nederland en België zijn met elkaar vergeleken. Hieruit wordt duidelijk dat het verschil in techniekeffect tussen Nederland en België vooral wordt veroorzaakt door het verschil in ambitieniveau van de emissie-eisen.

Een van de belangrijkste conclusies is dat afpelplaatjes richting kunnen geven aan de beleidsanalyse. Beleidsanalyses kunnen worden ondersteund door het afpelplaatje. Daarnaast kunnen beleidsanalyses ook verschillen met het afpelplaatje. In dit geval kunnen andere verklaringen worden gezocht voor veranderingen in het emissieverloop. Wanneer de combinatie beleid-afpelplaatje wordt gebruikt bij internationale beleidsanalyses, moet er rekening mee gehouden worden dat de methode veel tijd vraagt. Dit komt doordat het onderzoek zowel breed is als de diepte ingaat.

Summary

This report focuses on the linkages between emission reduction policies and decomposition figures to express the influence of policies on the emission course. Furthermore, the practicability of decomposition figures is investigated from the view of policy analysis at international level. Confirming effects of domestic and foreign policies on emission courses enables the comparison of national efforts in the field of emission reduction. Countries can discuss the emission reduction management of a certain country and may indicate that the efforts of that country will have to be enlarged.

The research questions have been answered on the basis of a case study concerning the reduction of NO_x-emissions originating from combustion plants in industry in the Netherlands and Belgium in the 1985-1999 period. There has been an effort made to link NO_x-emission reduction policies with the determinant technical effect. The development of decomposition figures and the description of policies have interacted resulting in the linkages between policies and decomposition figures. Furthermore, instrument characteristics developed by Van Wijk *et al.* (2001) were used for determining instrument effects. The instrument characteristics 'imperativeness', 'ambition level', 'range' and 'level of execution and enforcement' were applied in this study. Finally the linkages of the Netherlands and Belgium were used in the comparison of the policies of the two countries.

Decomposition figures had already been developed at the RIVM for the target group industry. In decomposition figures both the actual emission course and the underlying developments are made visible. The emission course is determined by the following determinants: scale effect, structure effect, energy intensity effect, fuel mix effect and technique effect. The decomposition figures already developed were adapted with a view to policy analysis. First, changes in emissions were calculated per year, instead of once in five years, because detailed decomposition figures facilitate recognition of effects of policies on the emission course. Next, the period was extended by 4 years, because a longer period would provide more information about developments in emission courses.
Policies were described simultaneously with the development of the decomposition figures. First, the international agreements of the Convention on Long-Range Transboundary Air Pollution (CLRTAP) (1979) and the Sophia protocol (1988) have been described, followed by the EC Directive of 1984 and 1988 on the combating of air pollution from industrial plants. The national policies of the Netherlands and Belgium were discussed after the international framework. Policy plans and instruments have been considered. Instruments represent the actual implemented measures and are thereby closely related to changes in the course of NO_x-emissions. Juridical instruments have been intensively investigated, because it was expected that these instruments influence the emission course to a large extent.

Several linkages were found between Dutch policies and the determinant technique effect. Linkages were found between the decree on emission limits of large combustion plants (BEES) and technique effect. Technique effect hardly developed in Belgium, which hampered the linking of policies to technique effect. The easy achievable emission limits of Belgium explain the absence of technique effect in Belgium. The linkages between policies and decomposition figures of the Netherlands and Belgium have been compared. This has led to the idea that differences in technique effect between the Netherlands and Belgium are caused by the difference in ambition level of the emission limits.

One of the most important conclusions is that decomposition figures can direct policy analysis. Decomposition figures can confirm expected changes in technique effect on the basis of policy analysis and, in doing so, underpin policy analysis. The interaction between decomposition figures and policy analysis can sometimes lead to discrepancies that may also direct policy analysis. Explanations have to be looked for in another direction.
The broad-based and in-depth studies take a lot of time, so if more countries are involved in the policy analysis the time-consuming aspect of this method has to be taken into account.

1. Introduction

Large-scale air pollution is a well-known theme in international environmental policies. This problem came up for discussion at the beginning of the 1970s, when transboundary air pollution was related to the degradation of Scandinavian lakes. Many investigations demonstrated the link between sulphur emissions in continental Europe and the acidification of Scandinavian lakes. Later studies confirmed that air pollutants, like sulphur dioxide (SO_2), nitrogen oxides (NO_x) and Volatile Organic Compounds (VOC) can travel several thousand kilometres before deposition and damage occur (www.unece.org/env/lrtap; Van der Straaten, 1990).

Transboundary air pollutants negatively affect nature, agricultural crops, materials and human health. Negative effects on nature find expression in decline of soil quality, increase in the aluminium and nitrate concentrations in the groundwater, root degradation of trees and plants and increased stress sensitivity of trees. These effects ultimately lead to degradation of nature and decrease in biodiversity. Transboundary air pollutants also lead to poor air quality, which negatively effects human health. NO_x, for example, is a reactive oxidising compound, which can react with tissues in the airways. Especially asthma and bronchitis patients experience negative effects from this (VROM, 2001).

In the last few decades many efforts have been made to solve the problem of transboundary air pollution at international and national levels. International agreements were laid down in the Convention on Long-Range Transboundary Air Pollution (CLRTAP) of 1979, which was signed by 34 countries and the EU. Under CLRTAP, several protocols on different types of pollutants were passed. The Parties to the CLRTAP and its protocols have the obligation to comply with the agreements. In the course of time countries have developed strategies and policies to reduce their emissions. In accordance with the agreements countries report periodically to the Economic Commission for Europe (UN-ECE) on the progress in policy-making and the actual emissions of pollutants. Compliance of the Parties with the agreements is controlled in this way. The differences between countries may be revealed through the exchange of national strategies and policies. For example, the reports prove that the degree of reduction differs per country (UN-ECE, 1994; UN-ECE, 1998 [niet op lijst, wel 1999]). The availability of transparent methodologies will provide a better understanding of differences in national circumstances between countries and their influence on current and future emission levels (Phylipsen, 2000).

A method to compare national differences will be worthwhile in several ways. The comparison of national efforts will be of interest for determining the degree of equality with respect to competition between countries. Moreover, the position of a country in relation to other countries can be determined for emission reduction. Countries can discuss the emission reduction management of a certain country and may indicate that the efforts of that country will have to be enlarged. Comparison of national efforts and emission courses may also promote insight into the options for emission reduction, since strategies and policies can be exchanged between countries. Summarising, methodologies for national comparisons will facilitate the comparison of national emission courses and will improve emission reduction. At international level, many investigations have been carried out on the development of a method for emission trend analysis. The RIVM developed a method based on articles by Selden *et al.* (1999) and Harmelink *et al.* (1995). Not only can this method sustain emission trend analysis of a certain country, it can also provide a better understanding of differences in national emission courses. The method quantifies the contribution of different developments underlying the course of emissions (Harmelink and Idenburg, 1999). The developments taken into account are found in the economic growth of the total industry as well as several sectors. Furthermore, the emission trend analysis makes use of the energy intensity and fuel mix used in industrial sectors. Emission reduction techniques are also applied as part of the method, and decomposition figures can be drawn to show the contribution of the determinants. Decomposition figures are already applied in the Environmental Balances of the RIVM to show the factors that cause emission reduction in the Netherlands.

Emission trends can be analysed to a certain extent using this method developed. The influence of policies on emission courses does not occupy an explicit position in the method, but is integrated in the influence of the other determinants. The influence of policies to emission courses is important for the determination of the effectiveness of policies and the comparison of national efforts.

Here, the focus will be the relationship between emission reduction policies and decomposition figures. In a case study links are sought between important policy events and changes in the course of decomposition figures to express policy effects. Furthermore, the practicability of decomposition figures is investigated from the view of policy analysis. The case study concerns reduction of NO_x-emissions from combustion plants in industries in the Netherlands and Belgium in the 1985-1999 period. There has been an effort made to link NO_x-emission reduction policies with the determinant technical effect. This case study was used in answering the following research questions:

1. How can emission reduction policies be linked to decomposition figures?

2. What is the value of decomposition figures in emission reduction policy analysis at international level?

2. Methods of investigation

Decomposition figures and an overview of important policy events are necessary in answering the research questions. Furthermore, the development of decomposition figures and the description of policies have to interact to gain insight into possible links. The research questions would hopefully be answered on the basis of a case study concerning the reduction of NO_x-emissions originating from combustion plants in industry in the Netherlands and Belgium in the period 1985-1999.

Rough decomposition figures were already developed at the RIVM. These decomposition figures are based on the method for emission trend analysis developed by Selden *et al.* (1999) and Harmelink *et al.* (1995). For policy analysis the decomposition figures had to be further developed. During the investigation it became clear in which manner the decomposition figures would be adapted. Necessary data were collected from the database of the RIVM and similar offices, statistical offices and international organisations. The NO_x-emission reduction policies had to be reconstructed for the two countries. The Netherlands and Belgium have developed policies in the international framework, which consists of international agreements and policies of the European Union. For this reason, first international conventions and protocols and EU policies were described, after which national policies were discussed. Instruments used to implement national policies were also described, because instruments have an important role in the connection between policies and emission courses. Special attention was paid to juridical instruments, which were expected to considerably affect emission courses. In addition to the description of the overall picture of NO_x-emission reduction policies attention was paid to events of special relevance for linking policies to decomposition figures. Examples are initiating new policy instruments or making changes in instruments or strategies.

Once policies were known and the figures developed, the next step was to find links between policies and decomposition figures. In this study, policies were linked to the determinant technique effect only, because the effects of NO_x-emission reduction policies would be best visible in the course of this determinant. This can be explained by the large extent of the influence of policies on this determinant. The instrument characteristics developed by Van Wijk *et al.* (2001) were used for determining its effect. An instrument characteristic can be seen as a specific part of the policy instrument design, so as to stimulate a company to act according to the behavioral standard, which this instrument imposes on it. The characteristics of the instrument developed correspond with suppositions related to the effect of policy instruments in the decision-making process of industrial sectors to invest in energy-saving measures (Van Wijk *et al.* 2001). Four out of the twelve instrument characteristics developed were specially applied in this study; these are ‘imperativeness’, ‘ambition level’, ‘range’ and ‘level of execution and enforcement’. Table 1 describes the instrument characteristics.

Finally, NO_x-emission reduction policies and the resulting effects of these policies were compared between the Netherlands and Belgium. This comparison would gain insight into the value of decomposition figures used in international policy analysis.

Table 1. Characteristics of instruments applied to this study (Van Wijk et al., 2001).

Instrument characteristic	**Description**
Imperativeness	The degree to which the instrument limits the freedom of companies within the sector.
Ambition level	The degree to which a change of existing behaviour is demanded from companies.
Range	The extent to which the instrument applies to the companies in a sector.
Level of execution and enforcement	The degree to which companies are monitored by public bodies in the employment of the instruments. Important is the level of knowledge within public bodies and their human resource capacity.

Case study

The case study concerns the reduction of NO_x-emissions originating from combustion plants on industrial sites in the Netherlands and Belgium in the 1985-1999 period. NO_x-emission reduction policies were linked to technique effect. Finally, the research questions had to be answered with the aid of the results of the case study.

This case study was chosen for several reasons. One of the reasons was the development of many policies concerning NO_x-emission reduction over a long period, which allows us to find various links between policies and decomposition figures. Moreover, the acidifying pollutant NO_x coincides with the focus of the project, which is acidification. Industry was chosen as target group, since decomposition figures had already been developed for industry. The investigation covers the 1985-1999 period, determined, in particular, by the availability of data. The year 1985 was chosen as the starting year, since data were available for this year and NO_x-reducing techniques had not been applied in industry so far. As a result, the unabated NO_x-emission course could be compared with the NO_x-emission course influenced by NO_x-reduction policies. The year 1999 was the closest year to the present with all the necessary data available

The Netherlands and Belgium are, as neighbouring countries, inter-compared. This implies a lot of interaction between the two countries, for example, through trade. The NO_x-emission reduction policies of the two countries were considered comparable. Later, Flanders was investigated separately from Belgium, because a technique effect was more likely in Flanders in contrast with the whole of Belgium. This would contribute to the investigation of the relationship between NO_x-reduction policies and the course of NO_x-emissions. So the three regions: Flanders, Wallonia and Brussels are represented in the decomposition figure of Belgium and Flanders.

3. Decomposition figures

3.1 Explanation of decomposition figures

The emission trend analysis method used in this study is based on the articles of Selden *et al.* (1999) and Harmelink *et al.* (1995). In this method the following determinants are distinguished: scale effect, structure effect, energy intensity effect, mix of fuels effect and technique effect. The following equations calculate the emission of a pollutant in a certain year (P_{ind}), taking into account the influence of the determinants:

$$P_{ind} = GPI_{ind} * SUM_{i,j}[(GPI_j/GPI_{ind}) * (E_j/GPI_j) * (E_{ij}/E_j) * (P_{ij}/E_{ij})]$$

$$= GPI_{ind} * SUM_{i,j}[S_j * I_j * F_{ij} * EM_{ij}]$$

GPI_{ind} : gross product of industry (GPI)
GPI_j : GPI of sector j in industry
E_j : energy use sector j
E_{ij} : energy use of fuel i in sector j
P_{ij} : emission of fuel i in sector j
S_j : contribution of sector j to GPI of industry
I_j : energy intensity of sector j
F_{ij} : contribution fuel i to energy use of sector j
EM_{ij} : emission intensity of fuel i of sector j

Each determinant affects the emission course in its own way. The degree of influence of the determinants differs between countries and in time. The determinant ‘scale effect’ represents the changes in the emission course as a result of changes in gross product of total industry. GPI is positively correlated with the degree of emission of pollutants. For example, NO_x-emissions will increase with growing GPI. ‘Structure effect’ takes the effect of the growth of industrial sectors into account. The composition of sectors in industry can change in time, because industrial sectors can grow faster or slower than total industry. Since industrial sectors emit different amounts of pollutants this will influence the emission course. The energy intensity of industry also influences the emission course. Energy intensity is positively correlated with the degree of emission. For example, decrease of energy consumption results in less combustion of fuels, and so, emissions decrease. Decrease in energy consumption can be realized by a higher energy efficiency, which may be reached by dematerialization and technical improvements (Farla, 2000). The determinant ‘fuel mix’ represents the influence of changes in fuel mix on the emission course. Fuel mix influences the emission course, because different types of fuels emit different amounts of pollutants. A shift in fuel use from coal to gas causes a decrease of emissions. The determinant ‘technique effect’ reflects the influence of the application of emission-reducing techniques in industry on the course of emissions.

The figures produced by the emission trend analysis method are called ‘decomposition figures’. The name ‘decomposition figures’ refers to the unraveling of the underlying developments of emission courses. In decomposition figures both the actual emission course and the underlying developments are made visible. The influence of determinants is made visible step-by-step by keeping other determinants constant. In the first stage the reference line is drawn. All determinants are kept constant at the values of the starting year, except the gross product of total industry. In this situation, the course of emission is made visible if GPI is the only determinant that changes in a certain period. In the second step, changes in the gross product of different industrial sectors are made variable, as well as changes in the gross product of total industry, while the remaining determinants are still maintained constant. In this situation the influence of the growth of industrial sectors is visible. In this way, all determinants become variable, making the actual emission course visible.

Policies are not explicitly included in the method of analysis but are expressed by the influence of the determinants. The degree of influence of policies is difficult to determine, because effects of policies are difficult to prove. The part of the effect of the determinant that is not influenced by policies is called autonomous. So the influence of a determinant on the emission course is the combined effect of autonomous developments and policies. The contribution of policies to the effect of a determinant is dependent on the policies developed. The NO_x-emission reduction policies of the Netherlands and Belgium hardly affect the determinants scale effect and structure effect. The determinants energy intensity, mix of fuels and technique effect are influenced by policies. Developments in energy intensity and mix of fuels are started or supported by policies that are not primarily focused on emission reduction. Policies, which influence technique effect, are primarily focused on emission reduction. Policies influence the determinant technique effect to the largest extent (Harmelink, 1999).

3.2 Decomposition figures of the Netherlands, Belgium and Flanders

3.2.1 Development of decomposition figures

Rough decomposition figures of the Netherlands and Belgium had already been developed at the RIVM for the period 1985-1995 (Figures 1 and 2). In these decomposition figures the fuel mix effect is subdivided into fuel mix 1, which represents the mix of energy use in the form of electricity and fuels, and fuel mix 2, which represents the mix of energy use in the form of coal, oil and gas. The decomposition figures were drawn from data from various sources. Data for the gross product of total industry and the industrial sectors of the Netherlands and Belgium originate from the report 'European Environmental Priorities: an Integrated Economic and Environmental Assessment' (2001). The energy statistics are taken from the International Energy Agency (IEA) and NO_x-emissions originate in the Program for Monitoring and Evaluation of the Long-range Transmissions of Air Pollutants in Europe (EMEP).

The decomposition figures already developed were adapted with a view to policy analysis. First, changes in emissions were calculated per year, instead of once in five years, because detailed decomposition figures facilitate recognition of effects of policies on the emission course. Too rough figures can smooth down effects of individual policy measures. Next, the period was continued to 1999, because a longer period would provide more information

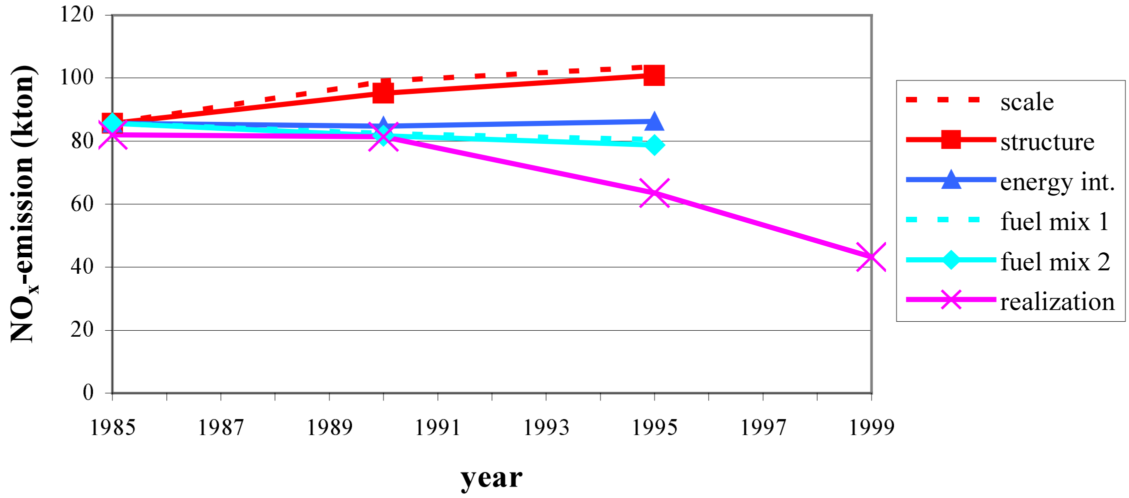

Figure 1. Rough decomposition figure of the NO_x-emission from combustion plants in the industry of the Netherlands in the period 1985-1995.

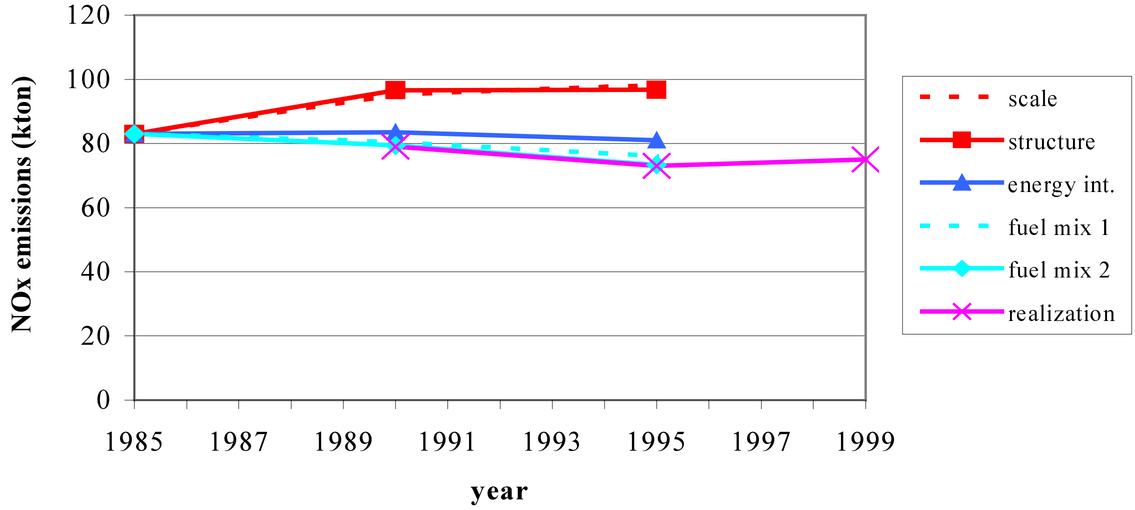

Figure 2. Rough decomposition figure of NO_x-emissions from combustion plants in Belgian industry from1985 to 1995.

about developments in emission courses. Besides, in the decomposition figure of the Netherlands (Figure 3), the effect of the technique was calculated with the aid of emission factors. In the first version of the decomposition figures of the Netherlands, the 'technique effect' was determined by the difference between the steps of 'fuel mix 2' and 'realization'. Statistics Netherlands (CBS) calculated emission factors per fossil fuel (NO_x-emission/energy use) of the Netherlands for the years 1990, 1995, 1998 and 1999. For Belgium (Figure 4) the 1990 emission factor for the Netherlands was used for all years. This emission factor will not deviate much from the emission factor for Belgium at that time, because no NO_x-reduction techniques had yet been implemented in either country at that time. The 'technique effect' was not calculated for Belgium. The application of techniques in industry for Belgium is indicated by the difference between the steps 'fuel mix effect 2' and 'realization'.

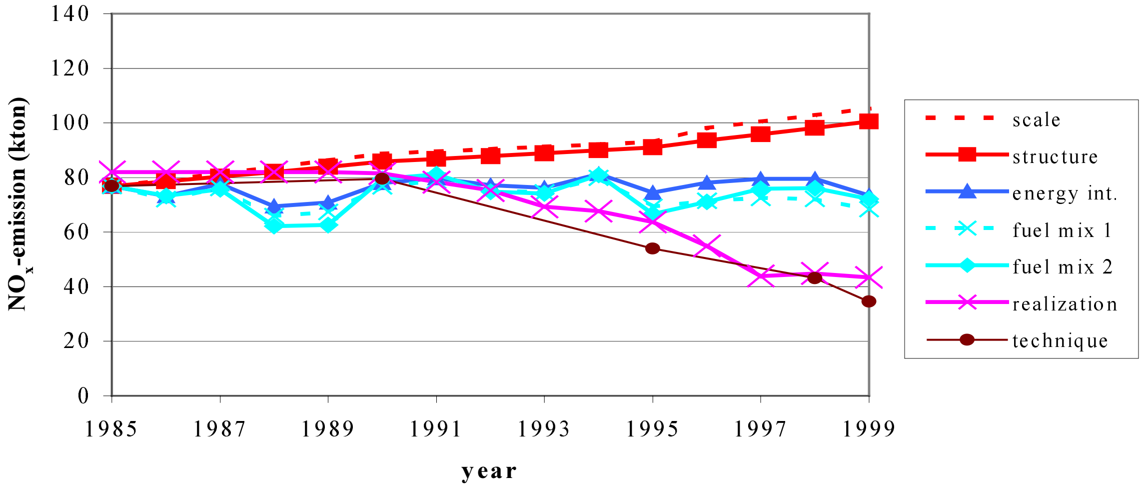

Figure 3. Detailed decomposition figure of the NO_x-emission of combustion plants in industry for the Netherlands from 1985-1999.

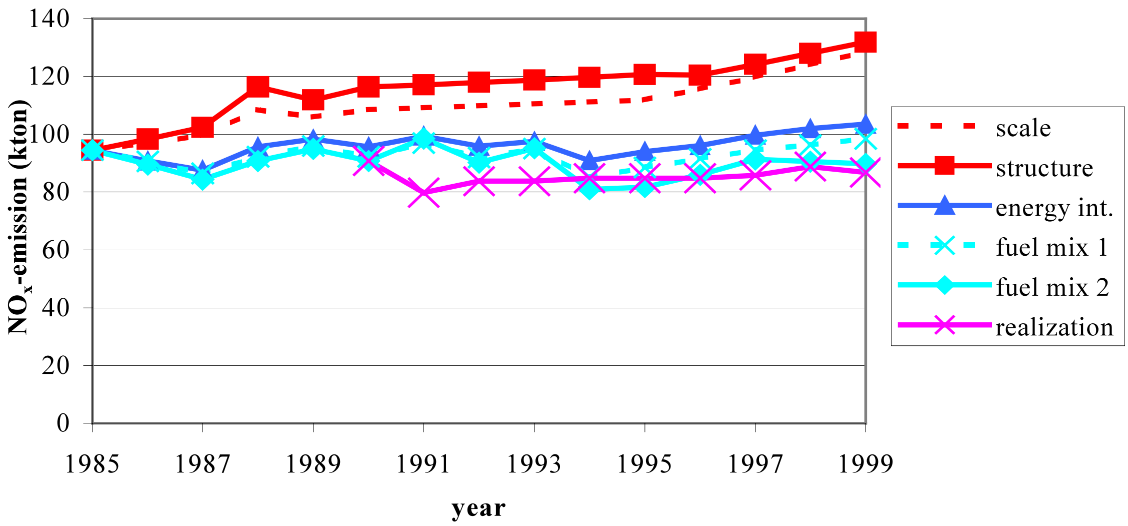

Figure 4. Detailed decomposition figure of the NO_x-emissions from combustion plants in industry for Belgium from 1985-1999.

A decomposition figure of Flanders was drawn to relate Flemish policies to technique effect. A technique effect was expected in Flanders, because Flemish policies concerning reduction of NO_x-emissions improved in the second part of the nineties. The decomposition figure of Flanders was composed in the same manner as the figures of the Netherlands and Belgium, except that the structure effect was left out. The gross product of individual sectors had to be calculated, which would have cost too much time. The Flanders data were collected from other sources than the data of the Netherlands and Belgium, because international organizations do not provide regional data of countries. The data on gross product of total industry originate in the National Bank of Belgium (NBB). Data were available for the year 1995 onward because a new method had been used after 1995. The gross industrial product for 1990 was calculated from these data. Energy statistics originate in the Flemish Institute for Technological Research (VITO). NO_x-emissions of combustion plants in industry were calculated by the Flemish Environment Agency (VMM). NO_x-emissions for Flanders seem too low in comparison with the decomposition figure. However, NO_x-emissions for Flanders seem also to be too low in proportion to the Belgian total NO_x-emissions originating in industry. The coefficient of the monitored NO_x-emission is equal to the coefficient of the calculated fuel mix line, implying that the technique effect is absent in Flanders (Figure 5).

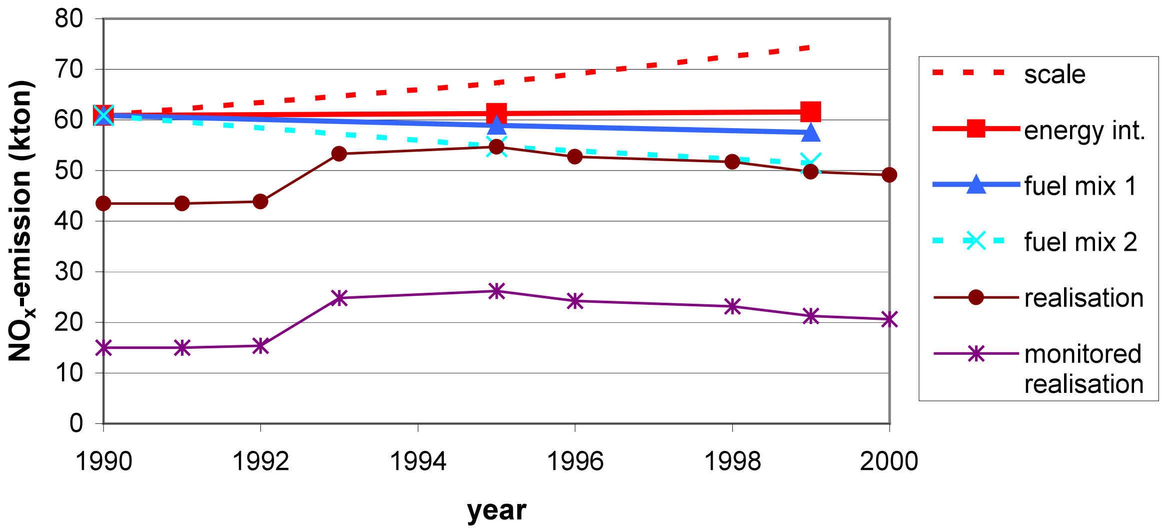

Figure 5. Decomposition figure of the NO_x-emission of combustion plants in industry for Flanders in the period of 1985-1999.

Reliability of data

Data necessary to draw decomposition figures are not always reliable on a large scale. This is caused by differences in data quality between countries and organizations and with time. Data are often subject to changes in methods of calculations. During the investigated period changes in methods took place for energy statistics, emission factors and NO_x-emissions. Monitored NO_x-emissions of Belgium and Flanders were not very reliable in the beginning of the nineties. A reliable emission registration has been established since 1996 in Flanders as a result of changes in legislation (VMM, 2001). So, working with decomposition figures requires attention for reliability of data.

3.2.2 Differences and similarities between decomposition figures

The decomposition figures for the two countries and Flanders differ mutually. These differences are the result of autonomous factors and policies. This section discusses the rough differences and similarities between the decomposition figures. The rest of the report focuses on the determinant technique effect and the relation between policies and the technique effect.

The gross product from total industry is increasing in the two countries and Flanders. When the other determinants remain constant this implies an increase in NO_x-emissions. The realized NO_x-emissions are also shown in the decomposition figures. NO_x-emissions decrease in the Netherlands and Flanders, while NO_x-emissions of Belgium remain constant. So an increase in GPI does not immediately imply an increase in NO_x-emissions. NO_x-emissions can even decrease with increasing GPI. This phenomenon is called decoupling of economic growth and environmental pressure (Hofkes *et al*., 1998).

Energy intensity plays an important part in the reduction of NO_x-emissions in the two countries and Flanders. The energy intensity of the Netherlands and Flanders fluctuates around the value of energy intensity in the starting year. This is also the case in Belgium, but a gradual increase has been visible since 1994. The effect of energy intensity is the combined result of autonomous factors and policies. An example of an autonomous factor is energy saving by industry to lower the production costs. Policies stimulate energy-saving concerned with CO_2 reduction, which abates the greenhouse effect. A side effect is reduction of NO_x-emissions.

The ‘technique effect’ also plays an important part in the NO_x-emission reduction of the Netherlands. However, the decomposition figures of Belgium and Flanders do not show the ‘technique effect’. The influence of this determinant is also ascertained by autonomous factors and policies. An example of an autonomous factor is purchase of new techniques, which furnish better results than old techniques. Besides, new techniques emit less NO_x than old techniques. Nevertheless, purchase of NO_x-reducing techniques is influenced by NO_x-reduction policies for the largest part, because NO_x-reducing techniques do not yield a profit for industry.

In the Netherlands energy intensity and the effects of technique have obviously contributed to NO_x-emission reduction in the investigated period, while the contribution of the other determinants was minor. In Belgium and Flanders the contribution of the determinant mix of fuels is of consequence. A shift in the use of solid and liquid fuels to gaseous fuels has contributed to a decrease in NO_x-emissions. This effect is less visible in the decomposition figure of the Netherlands, because the use of gaseous fuels was at a constant high level during the period 1985-1999.

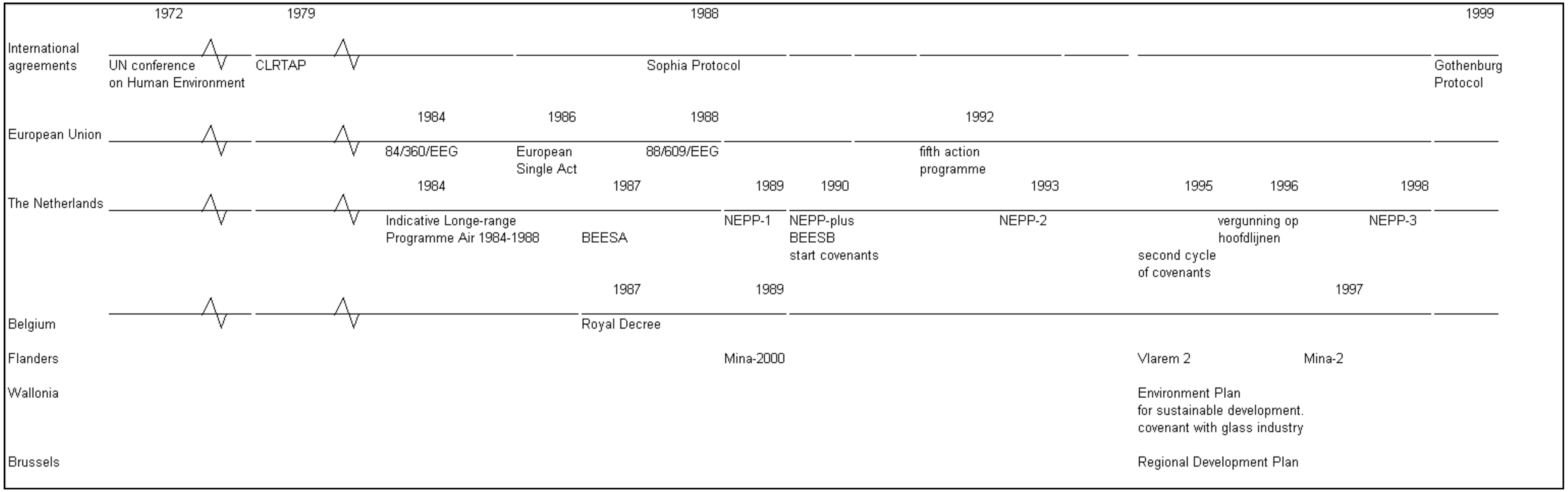

Figure 6. Overview of important events concerning NO_x-emission reduction policies.

4. Policy context

NO_x-emission reduction policies have been developed during the last three decades. The development of NO_x-emission reduction policies started at international level with international agreements, after which European policies were developed. International and European policies form the international framework in which national policies have to be developed. In spite of the same framework, national policies differ in several aspects. This section considers the policy events of scheme 1. First, the international framework will be discussed, followed by the national policies of the Netherlands and Belgium. The instruments used to implement national policies will also be considered. Instruments represent the actual implemented measures and are thereby closely related to changes in the course of NO_x-emissions.

4.1 International agreements

The problem of transboundary air pollution came up for discussion at the conference of the United Nations (UN) on Human Environment in Stockholm in 1972. At the conference countries declared themselves unprepared to take measures but decided to carry out extensive research. Between 1972 and 1977 several studies confirmed the hypothesis that air pollutants could travel several thousands of kilometres before deposition and damage occur. In response to these findings a high-level meeting within the framework of the Economic Commission for Europe (ECE) was held at ministerial level in Geneva in 1979. It resulted in the signature of the Convention on Long-Range Transboundary Air Pollution (CLRTAP) by 34 governments and the European Community (EC). The CLRTAP was the first legally binding instrument to abate air pollution on large scale and contributed to the development of international environmental laws. Under the CLRTAP several protocols passed, including the Sofia Protocol in Bulgaria (1988) (www.unece.org/env/lrtap). The Parties to the 1988 Sofia Protocol on the control of NO_x-emissions have the obligation to stabilise NO_x-emissions by the end of 1994 at 1987 levels. Almost all parties to the protocol reached this objective. In addition twelve parties made a declaration to the effect that they will aim for a reduction of NO_x-emissions in the order of 30%, based on emission levels of any year between 1980 and 1986 as soon as possible and at the latest by 1998 (UN/ECE, 1994).

The parties to the Sofia Protocol have to meet a number of obligations. Box 1 shows the relevant agreements for NO_x-emission reduction in industry. The main points are establishing critical loads, applying emission standards, based on the Best Available Technologies Not Exceeding Excessive Costs (BATNEEC) for new stationary sources, and introduction of control measures for existing stationary sources. Furthermore, countries have to develop national policies and strategies to implement the obligations of the Protocol.

Box 1. Parts of the Sophia Protocol relevant for NO_x-emission reduction in industry.

- The Parties have to apply emission standards, economically feasible and based on the best available technologies, to major new stationary sources. Pollution control measures have to be introduced for major existing stationary sources, taking into account the characteristics of the plant.
- The Parties shall, as a second step, commence negotiations, no later than six months after the date of entry into force of the Protocol, on further steps to reduce national annual

emissions of nitrogen oxides, taking into account the best available scientific and technological developments and internationally accepted critical loads. To this end, the Parties shall co-operate in order to establish critical loads and reductions in national annual emissions of NO_x as required to achieve agreed objectives based on critical loads. Measures and timetable have to be determined no later than 1 January 1996. The Parties may set stricter emission reductions than internationally agreed.
- The Parties shall facilitate the exchange of technology to reduce emissions of nitrogen oxides.
- The Parties shall regularly review the present Protocol, taking into account the best available scientific substantiation and technological development. The first review shall take place no later than one year after the date of entry into force of the present Protocol.
- The Parties have to investigate the effects of NO_x on environment, nature and humans to determine critical loads. Further investigation has to be carried out to the scale of Transboundary air pollution. The Parties also have to develop methods in order to determine appropriate control strategy.
- The Parties shall develop national programmes, policies and strategies to implement the obligations under the present Protocol.
- The Parties shall annually exchange information about their national programmes, policies and strategies to the Executive Body (www.unece.org/env/lrtap/)

In 1999 different countries signed the Gothenburg Protocol for the abatement of acidification, eutrophication and ground-level ozone. The Protocol sets emission ceilings for 2010 for four pollutants: sulphur, NO_x, VOCs NH_3. Once the Protocol is fully implemented, Europe's NO_x-emissions will be reduced by 41% compared to 1990. The Protocol also sets tight limit values for specific emission sources, including combustion plants. This points to an increasing imperativeness at international level. However, the Gothenburg Protocol has no influence on the emission course of the 1985-1999 period and will therefore not be further discussed.

4.2 European policy

After the international agreements were set up, policies on NO_x-emission reduction were developed at European level. The EU has the largest influence on national environmental policies of all international organisations. Since 1972 the EU has drawn up five environmental action programmes (www.europa.eu.int). The first four action programmes were of less interest. Since the signing of the European Single Act in 1986 environmental policies became an explicit responsibility of the EU. The EU also includes harmonisation of environmental policies of the individual Member States in its field of work. The guideline for the Fifth Action Programme of the European Commission is called sustainable development (Van der Straaten, 1994a). In the Fifth Action Programme the basic principles of a European strategy were established for the period 1992-2000 (www.europa.eu.int). The National Environmental Policy Plan (NEPP) of the Netherlands can be recognised in this action programme. One of the similarities is the framework, which still has to be converted into concrete measures. Directives normally express the influence of the EU. Policies are established in directives that have to be implemented by Member States. EC directives are not always completely implemented (Van der Straaten, 1994a).

European policies on NO_x-emission reduction in industry

In 1981 the EU became a member of the Convention of Transboundary Air Pollution (CLRTAP). As a result of this membership and the Action Programme of 1983 the Commission's ambition was to establish air quality standards and emission standards. In 1984 the EC Directive (84/360/EEG) on the combating of air pollution from industrial plants was drawn. The purpose of this directive is to provide for further measures and procedures designed to prevent or reduce air pollution from industrial plants within the Community. Various measures have to be met by the Member States (Box 2).

Box 2. Parts of the EC Directive on combating air pollution from industrial plants (1984) (www.europa.eu.int).

- Authorisation of different industrial plants is required.
- Authorisation may be issued only when the competent authority is satisfied that all appropriate preventive measures against air pollution have been taken, including the application of the best available technology, provided that the application of such measures does not entail excessive costs.
- Member States shall exchange information among themselves and with the Commission regarding their experience and knowledge of measures for prevention and reduction of air pollution, as well as technical processes and equipment and air quality and emission limit values.
- The Council shall if necessary fix emission limit values based on the best available technology not entailing excessive costs.
- The Member States shall implement policies and strategies for the gradual adaptation of existing plants to the best available technology. Member States may adopt provisions stricter than those provided for in this Directive.

No emission limits were set in the EC Directive of 1984. In the Fourth Action Programme (1987-1992) special attention was paid to air pollution abatement at the source. Emission limits were determined in the EC Directive of 1988 (88/609/EEG) on the limitation of emissions of certain pollutants into the air from large combustion plants for SO_2, NO_x and dust emitted by new large combustion plants with a capacity of 50 MW and over. These use solid, liquid or gaseous fuels. NO_x-emission limits of the 1988 EC Directive were tightened up in 1998 and 2001. Appendix 2 presents an overview of the emission limits. Member States were also obliged to draw up programmes to reduce SO_2 and NO_x-emissions originating from existing combustion plants. The date on which the construction licence is granted or in absence of such a procedure, the operating licence, determines if a combustion plant is called existing or new. The licence of an existing combustion plant was granted before July 7, 1987 and the licence of new combustion plants on or after this date. The obligations for the Member States, which were included in the directive, are mentioned in Box 3.

Box 3. Obligations of the EC Directive of 1988, on the limitation of emissions of certain pollutants into the air from large combustion plants. Only the obligations are mentioned which are of interest for reduction of NO_x-emissions originating in industry.

- Not later than 1 July 1990, Member States shall draw up appropriate programmes for the progressive reduction of total annual emissions from existing plants. The programmes shall set out the timetables and the implementing procedures.
- Member States shall take appropriate measures to ensure that all licences for the

construction or, in the absence of such a procedure, for the operation of new plants contain conditions relating to compliance with the emission limit values of NO_x.
- In order to ensure compliance with the emission limit values for NO_x the licences may require appropriate design specifications.
- Member States have to measure the emissions.
- The measuring methods and/or equipment used in order to determine the concentrations of NO_x shall correspond to the best industrial measurement technology and shall provide reproducible and comparable results.
- Member States shall annually present the Commission a briefly report about the results of implementation of the programmes (www.europa.eu.int, EC Directive 88/609/EEG).

The entry into force of the 1988 EC Directive was an important step in the process for reducing NO_x-emissions originating in industry. Countries have to meet fixed standards, which are equal for all countries. So the imperativeness of NO_x-reduction policies increased with the appearance of the EC Directive of 1988. The Netherlands and Belgium implemented this directive and from then on emission limits were applied to new large combustion plants.

4.3 National policies for NO_x-emission reduction in industry

The Netherlands and Belgium signed the CLRTAP and Sofia Protocol. Both countries also made an additional declaration to the Sofia Protocol, which consisted of a reduction of NO_x-emissions in the order of 30% in 1998 based on emission levels of any year between 1980 and 1986 (UNECE, 1994). The Netherlands and Belgium also have to implement EU directives. So the international framework and thus the international pressure was the same for the Netherlands and Belgium.

Although the development of environmental policies in the Netherlands and Belgium took place in the same framework, policies can differ between the two countries. For example, they may require compliance with emission limit values and time limits for implementation which are more stringent than those set out in the 1988 EC Directive, they may include other pollutants, and they may impose additional requirements or adaptation of plant to technical progress. So the international agreements and EC Directives set minimum standards and Member States are able to formulate more ambitious objectives. The following section will consider NO_x-emission reduction policies of the Netherlands and Belgium.

4.3.1 The Netherlands

The policy plans, instruments and implementation process are described to gain an insight into the realisation of NO_x-emission reduction in industry. Environmental policies have been drawn in National Environmental Policy Plans (NEPP) which appeared since 1989. The most important instruments are the decree on emission standards of combustion installations (BEES), permits and voluntary agreements. Implementation takes place in a cyclic process, in which different phases have to be traversed by government and industry (Hoek *et al.*, 1998).

4.3.1.1 Policy plans

Policies concerning NO_x-emission reduction began to develop in the middle of the eighties. In the Indicative Long-Range Programme on Air (1984-1988), which was the second report in a series of yearly updated Long-Range Programmes, concerning air pollution abatement, a strategy was drawn up to determine emission limits for stationary sources. This strategy described precisely in which way emission limits would be set. It was intended to set emission limits for existing and new plants separately. Besides, emission limits for new plants would be determined by the concept of ‘state of technique’. This concept was introduced in conformity with the approach to the EC Directive of 1988 on air pollution abatement caused by industrial plants, which was in the making at that time. Emission standards would be set down in a decree. Drafts of this decree were published in 1985 (Indicative Long-Range Programme Air 1984-1988). Since the Decree on emission standards for combustion installations (BEES) in 1987, the stimulus from NO_x-reduction policies in industry became stronger (Van Peppel *et al*., 1998).

From the reports ‘Our Common Future’ (1987) by the Brundtlandt Commission and the report ‘Concern for Tomorrow’ (1988) of the National Institute for Public Health and Environment (RIVM), the conclusion was drawn that intensification and broadening of environmental policies were urgent and that sustainable development would take decades. This social and international pressure led to the appearance of the first National Environmental Policy Plan (NEPP) in 1989. In this plan a strategic medium/long-term plan had been drawn up for environmental policies for the first time. The strategy aimed at realising sustainable development. NEPP-1 covers the period 1990-2010 and contains the policy actions, which were, in any case, needed during the 1990-1994 planning period to get the desired development going.

NEPP-1 (1989)

Acid deposition objectives were formulated in NEPP-1 for realisation in 2000 and 2010. The ultimate objective of 1400 acid eq./ha was to be realised in 2010. This objective was determined assuming that the most serious effects of acidification would be prevented at the level of 1400 acid eq./ha. To increase the chance of success, an interim objective of 2400 acid eq./ha was set for the year 2000. Realisation of this interim objective would ensure protection of some of the forest areas and nature reserves. Emissions of acid pollutants had to be substantially reduced to bring the acid deposition levels down from 5300 acid eq./ha in 1987.

Emission reductions were determined per pollutant and per target group, which fitted in the theme- and target group approach of NEPP-1. Although the emission reduction objective for NO_x-emissions in industry is of interest for this study, the NO_x-emission reduction objective was set for industrial plants and refineries collectively. Industrial plants and refineries were to emit a maximum of 66 kton in 1994 and 38 kton in 2000. This would mean reductions of 20 per cent in 1994 and 54 per cent in 2000 with respect to the NO_x-emissions of 1985. Besides emission reduction objectives for the total industry, NO_x-emission ceilings were to be set for branches of industry and individual companies in co-operation with industry and the authorities concerned.

The NO_x-emission reduction objectives for industry had to be realised with the aid of measures. Two types of measures were implemented during the planning period emission-oriented and structural source-oriented measures. Emission-oriented measures involved the application of NO_x-reducing techniques. Structural source-oriented measures, such as energy saving, allow an integral approach to environmental problems with a view to sustainable development. The introduction of low-NO_x gas turbines and low-NO_x combustion plants was stimulated during the NEPP-1 planning period (emission-oriented measures). Furthermore, industry was encouraged to save energy (structural source-oriented measure), which would also reduce NO_x-emissions.

Supporting activities were also developed for a more effective implementation of NO_x-emission reduction measures, for example, the development of environmental concern systems by enterprises. Companies could outline their environmental objectives and strategies to reach these objectives in an environmental concern system. The development of environmental concern systems strengthen the responsibility of industry (NEPP-1, 1989). NEPP-1 attracted attention at international level (Van der Straaten, 1994a), because the traditional approach geared to individual treatment of air, water and soil problems was replaced by an integral policy approach geared to themes connected to long-term objectives. This was a whole new approach in environmental policy. The Dutch approach of integral policy planning was transferred to important parts of the Fifth Environmental Action Programme of the EU (NEPP-2, 1993).

NEPP plus (1990)

NEPP plus (1990) appeared a year after NEPP-1. In NEPP plus the policies of NEPP-1 were intensified, a necessary step for the reaching of the long-term objectives of NEPP-1. The NO_x-emission objective for 2000 of 37 kton for industry and refineries collectively was even tightened up to 26-29 kton, which would mean a reduction of 65-69 per cent in respect to 1985. So the ambition level was strengthened for NO_x-emission reduction in industry. Policy intensification concern earlier implementation of emission-oriented and structural measures, implementation of additional measures and strengthening of international strategies.
The 'NEPP-supervisory committee for industry' was instituted for the implementation of NEPP-1 policies in industry. So this is an extra activity to support industry to implement the measures. Through consultation within the committee the government authorities and industry were able to come to an agreement about approach, emission standards and measures. Target group policy would be implemented step by step, with emission standards and measures becoming more specific for sectors of industry and individual enterprises with each step (see implementation).

Besides controlled implementation of NEPP-1 policies, additional emission-oriented and structural measures were set up; these would become perceptible in the 1997-1999 period. These additional measures consist of:
- Additional energy savings, which would lead to a NO_x-emission reduction of 15 kton in 1995.
- Stimulation of the newest NO_x abatement technologies for gas turbines.
- Stimulation of low-NO_x gas motors with the aid of subsidies and demonstration projects.
- Demonstration projects for low-NO_x combustion plants in industry.

These additional measures were meant mainly to encourage industry to implement the NO_x-reducing measures, especially the Decree on emission limits for large combustion plants (BEES) (see section 4.3.1.3).

NEPP-2 (1993)

NEPP-1 and NEPP plus set objectives and strategies for NO_x-emission reduction for the 1990s. NEPP-2 focused mainly on the implementation of policies. Plans concerning strengthening of implementation were developed with the aid of the report 'NEPP Evaluation for industry', in which experiences of industry with policy measures were described.
When implementation of NEPP-1 and NEPP-plus was evaluated it was found that NEPP-1

policies had been translated relatively fast into assignments and facilities for large-sized enterprises. However, the acid deposition objectives of NEPP-1 would not be reached with current efforts. The implementation of measures by small and medium-sized enterprises formed the bottleneck. This group needed, by virtue of its nature, a wider range of instruments and reinforced implementation structures. In short, this means that NO_x-emission reduction policies were not successfully implemented in all parts of the range. NEPP-2 also paid attention to the implementation of policies by small and medium-sized enterprises. The supporting approach of policy implementation was continued and strengthened by measures that focused on research, pilot-plant tests and demonstration projects. However, NEPP-2 measures aimed at NO_x-emission reduction in industry would not have effect on the emission course of the1985-1999 period. Effects of NEPP-2 measures were expected after 2000 (RIVM), since most measures were related to replacement investments.

NEPP-3 (1998)

In NEPP-3 policies entered the phase of management. De-coupling economic growth and environmental pressure had to be maintained. The progress in abatement of acidification and NO_x-emission reduction in industry was evaluated. Results showed that the decrease in NO_x-emissions had been too little to manifest in environmental quality. The NO_x-emission objective of 26-29 kton for industry and refineries for the year 2000, which had been set in NEPP plus, was not considered achievable. The NO_x-emissions originating in industry were expected to decrease till 2000 and increase without additional measures after this year. This increase in NO_x-emissions could be explained by a rise in population and economic growth. For this reason the NO_x-emission reduction objective for 2000 was moved up to 2005, thereby weakening the NEPP-plus increased ambition level in the approach to the target date. The realisation of NO_x-emission reductions in industry depends on the availability of new cost-effective technologies and progress in EU legislation. Additional social efforts and costs will be necessary to reach the NO_x objective.

4.3.1.2 Implementation of NO_x-emission reduction policies

An implementation approach was developed in 1990 to further the implementation of NEPP-1 and NEPP-plus policies. This approach was geared to the translation of NO_x-emission reduction objectives of total industry into objectives for industrial sectors and individual companies by consultation between industry and authorities. The implementation process is a cyclic process, which means that some steps are traversed more than once. The implementation approach was composed of the following steps:

a. First environmental assignments are formulated per branch of industry. In 1990 a start was made on setting out assignments for the years 2000 and 2010. The objective was to formulate environmental assignments for all industrial sectors for the year 1990.
b. Next, Declarations of Intent are created for a number of selected branches of industry. These declarations, composed of the Integrated Environmental Targets (IET) for the sector, mark the beginning of the consultation between the branch of industry and the authorities. At the same time, publicity campaigns are launched, which have to increase the knowledge of companies about measures. In these campaigns the IETs for the branch of industry are explained to individual companies and authorities and indications are given for what already can be done to realise IETs.
c. In the third phase the results of the consultation with the branch of industry are set down in an implementation plan.
d. In the last phase implementation takes place at the level of individual companies. The

companies develop environmental concern systems, which facilitate attainment of the assignments by integration of environmental aspects in operational management. In 1990 it was the aim to have environmental concern systems for the 10,000 most polluting companies in 1995 (Milieuprogramma 1991-1994; NEPP plus, 1990).

The implementation approach was successfully used in practice. Almost all sectors of industry signed a Declaration of Intent during the early 1990s and in 1992, 90 per cent of the environmentally relevant companies were developing an environmental concern system. During the second half of the 1990s a second cycle of environmental concern systems started (Milieuprogramma 1994-1997). The progress in realising the implementation construction was probably also the result of the 'NEPP supervisory committee for industry', which was institutionalised in 1990. This committee formed the basis of an implementation-oriented consultative structure. Furthermore, an office was set up at VROM to assess and guide projects for environmental concern in companies in 1990 (NEPP plus, 1990).

Juridical, financial and communicative instruments contributed to the implementation of NO_x-emission reduction policies at the level of individual companies. The juridical instrument BEES, which set emission limits for combustion plants, has played an important part in reduction of NO_x-emissions (Poorter *et al*., 1996; Milieuprogramma 1997-2000). NO_x-emission limits were also determined by demonstration projects and consultation between industry and the government authorities (Milieuprogramma 1991-1994), which has probably led to a social basis for this instrument. The compliance with BEES was also supported by permits and voluntary agreements (VROM, 1992). Voluntary agreements are a communicative instrument and consist of consultation between industry and the authorities. Voluntary agreements increase the environmental consciousness of companies (Hoek *et al*., 1998). The implementation of BEES was also supported by financial instruments, for example, the subsidies granted for low-NO_x gas engines at the beginning of the 1990s (Milieuprogramma 1991-1994).

4.3.1.3 Instruments

Decree on emission limits of large combustion plants

The NO_x-emission reduction objectives for total industry and industrial sectors have to be reached by NO_x-emission reduction at the level of individual companies. BEES is an instrument that has set NO_x-emission limits at the level of combustion installations. The emission limits that have to be met by a company depend on the installations used. For example, the capacity of the installation will depend on whether BEESA (1987) or BEESB (1990) is applied to the installation. BEESA is used to set emission limits for installations with a thermal capacity of 50 MW and over, while BEESB is for emission limits for installations with a thermal capacity between 0.9 and 50 MW. This split was necessary for an equal division of efforts among individual companies.

In appendix 3 and 4 the emission limits are shown for BEESA and BEESB, respectively. In the schemes it can be seen that emission limits are also dependent on date of authorisation, type of installation and type of fuel. Date of authorisation is one of the categories because the availability of NO_x-reducing techniques increases in time. Existing installations can not immediately be replaced by new ones because of the costs. Tightened up emission limits are therefore usually applied to installations authorised after the date of commencement of the stricter emission limits. Another category that determines emission limits is type of installation. An important division is that between combustion plants and furnaces. With reference to the control of chemical reactions, combustion in furnaces has to meet particular demands These demands conflict with NO_x-emission control conditions. For this reason, emission limits for furnaces are less strict than limits for other combustion plants. The type of fuel used in combustion installations also determines the emission limits that have to be met. The fuels, coal, oil and gas, have different emission factors for NO_x. The emission factor indicates the amount of NO_x that will be released by combustion of a fixed amount of fuel. The higher the emission factor, the higher the release of NO_x will be. Coal has the highest emission factor followed by oil. Gas has the lowest emission factor. As a result stricter emission limits can be set for a combustion installation that uses gas as fuel than for an installation that uses oil.

BEESA and BEESB have undergone changes aimed at achieving the emission objectives. Only the changes undergone by BEESA will be considered in this study, since it was expected that changes in BEESA would lead to changes in the course of NO_x-emissions (see section 5.1). BEESA came into force on 29 May 1987 and implemented the EC Directive of 1988 on the limitation of emissions of certain pollutants into the air from large combustion plants. Only combustion plants authorised after this date had to meet the emission limits of BEESA. This is called the first phase. In the following phases BEESA emission limits were tightened up, whereas the emission limits of the EC directive of 1988 were tightened up for the first time on 1 January 2000. The BEESA emission limits were also gradually tightened up, while the emission limits of the EC Directive of 1988 were firmly tightened up in one go. On the average the BEESA emission limits were stricter than those of the 1988 EC Directive in the investigated period (compare appendix 3 with appendix 4).

In the second phase, which started on 1 August 1988, emission limits were tightened up for the first time. The first two phases were adopted to evaluate the experiences with low-NO_x burners. In 1989 emission limits were, for the first time, set for existing installations authorised before the date of commencement of BEESA. This forms another difference with the EC Directive, since no emission limits for existing installations were set by the EC Directive of 1988. On 15 October 1992 the third phase was started; here, emission limits were tightened for new and existing installations. The substantial tightening up of emission limits for existing installations is notable. Strict emission limits had to be met during the interim period of 1992-1998, allowed at the companies' request. The third phase implemented the intended measures announced in NEPP-1 and in the Abatement Plan Acidification, aimed at reaching the acidification objective for 2000. In 1992 emission limits were included in BEESA with the intention of enforcing them in 1994, the so-called fourth phase. After evaluation of the results of a demonstration programme, it was decided not to implement these limits. Uncertainties about the feasibility of the emission limits still existed for some of the plants. In this case consultation between authorities and industry resulted in the cancellation of stricter emission limits.

Emission limits were tightened up in 1998, but were less stringent than the limits that would come into force in 1994. Preparation of and consultation on the options for further NO_x-reduction took place in the NEPP-2 planning period. In NEPP-3 was mentioned which policy measures would be taken. Stricter emission limits were only applied to new installations, because the period of 1992 till 1998, in which existing installations had to purchase new techniques, was taken into account. It was prevented that companies, who had just purchased expensive techniques, were prevented from replacing these installations by new ones (BEESA, 1987).

Permits and covenants

BEES is directly applied to combustion plants, which makes companies themselves responsible for compliance with the emission limits. Nevertheless, BEES needs permits and voluntary agreements for implementation. Permits are juridical instruments and voluntary agreements are communicative instruments (Van Wijk *et al.*, 2001), which means that the imperativeness of permits is larger than that of voluntary agreements (Poorter *et al.*, 1996). Emission limits are fixed in company permits. Compliance with BEES is controlled during control and enforcement of permits. Companies covered by BEESA are controlled by the provincial authorities and companies covered by BEESB are controlled by the local authorities. When BEES is not or not completely implemented sanctions will be enforce (BEESA, 1987).

The first voluntary agreements were made in the early nineties. Voluntary agreements may contain objectives, emission standards and/or measures. Several forms of covenants exist, like Declarations of Intent and environmental concern systems (Hoek *et al.*, 1998). Although results of voluntary agreements can not be proven, it is expected that covenants will positively influence implementation of policies (VROM, 1992). Positive influence of covenants is felt in the creation of a social basis. Furthermore, covenants provide stability in the future for both industry and government authorities, along with the active involvement of companies in environmental problems (Hoek *et al.*, 1998).

One of the actions of NEPP-2 was the linking of environmental concern systems to environmental permits. The degree to which an environmental concern system is developed determines the kind of permit of a company. Four phases of environmental concern were distinguished: defensive, progressing , active and pro-active. Permits sketched in outlines recompense (pro-)active enterprises. These permits consist mainly of targets and much fewer requirements. These enterprises also have to deal with a different kind of enforcement. Companies are supervised less frequently and are only monitored on main points. Defensive companies are confronted with traditional permit granting and enforcement (Milieuprogramma 1997-2000). So companies, which take the environment into account are recompensed with increased freedom for action (imperativeness).

4.3.2 Belgium

4.3.2.1 Institutional context

In the two decades leading up to 1993, Belgium went through a series of institutional reforms, which transformed the country into a federal state made up of three regions and three language communities. The three regions are Flanders, Wallonia and Brussels. The three communities are French, Flemish and German. The Federal government, the three regions and the three language communities, which are equal under the law and exercise their responsibility independently in various fields, share decision-making power. The federation, communities and regions each have their own Parliament and government. The Flemish community and region have the same entity, so there are a total of six authorities and parliaments (Figure 7). The regions have the authority to independently negotiate and sign international treaties relating to the policy for which they have exclusive responsibility (OECD, 1998).

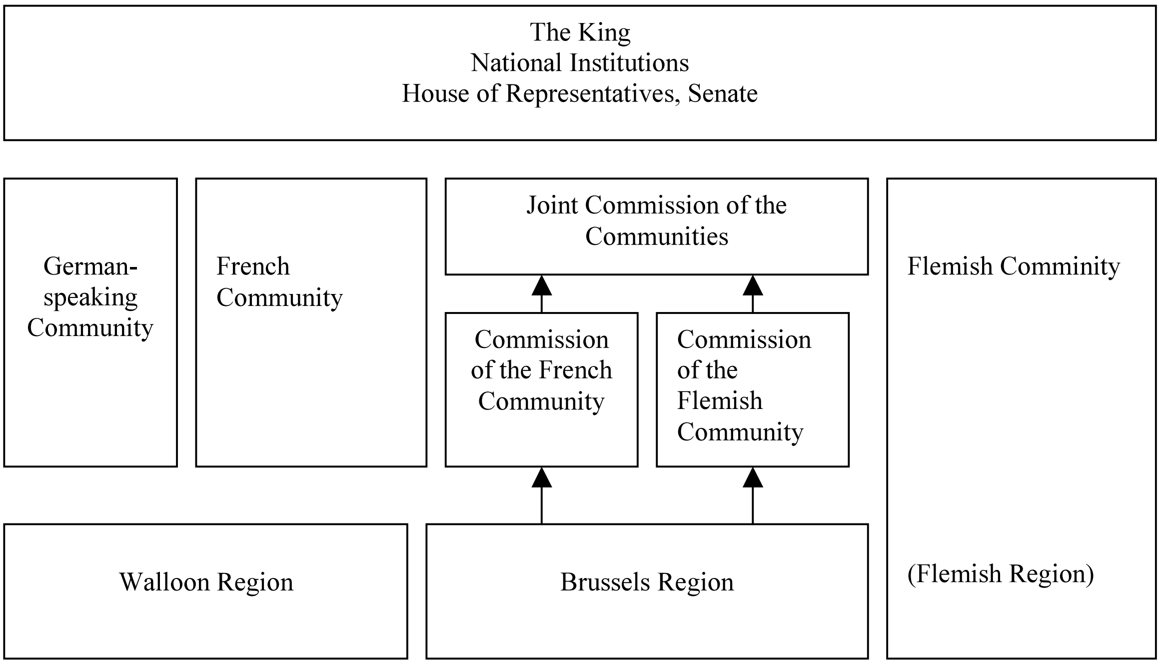

Figure 7. Belgium's institutional structure (OECD, 1998).

With the passing of the Special Institutional Reform Law of 1980, environmental protection, nature conservation, waste and water management and spatial planning became regional responsibilities (OECD, 1998). Implementation of EC Directives became a responsibility of the regions in 1988 (VROM, 1990). Federation and regions have responsibility for different environmental fields. The federation retains competence and enforces legislation related to coastal pollution, emissions for motor vehicles, product certification, transport of waste and sustainable development. Regional governments control emissions to air and water and control treatment and disposal of waste (VROM, 1990). So control of industrial emissions is the responsibility of the regions. The federal government is able to set minimum national standards by unanimously agreed Royal Decree. Belgium's complex environmental institution framework includes several co-ordination mechanisms, such as the Interministerial Conference on the Environment, the International Environmental Policy Co-ordination Committee and the Interregional Cell for the Environment (IRCEL/CELINE).

Until 1993 the main environmental policy considerations were procedural. Division of competencies between federal and regional authorities was the central point. In this period the main national development was the introduction of the Royal Decree on prevention of air pollution caused by new large combustion plants (VROM, 1990). The uncertainty associated with this long period of change may partly explain why Belgium has not made the same environmental progress as a number of other OECD member countries (OECD, 1998).

4.3.2.2 Policy

Belgium's NO_X-emission reduction objectives are largely determined by its international commitments:

- Sofia Protocol (1988): stabilisation of total NO_X-emissions at 1987 levels by 1994 and a reduction of 30 per cent by 1999, compared with 1986 levels.
- EC Directive on large combustion plants (1988): a reduction of NO_X-emissions from large combustion plants of 30 per cent by 1998, compared with 1980 levels (OECD 1998).

NO_x-emission reduction policies were for the most part developed by the regions because the federal government has had no responsibilities in the field of emissions to air by stationary sources since 1980. The federal government only has the competence to set minimum emission standards (minimum ambition level) and minimum range by the unanimously adopted Royal Decree (VROM, 1990). In 1987 the federation introduced the Royal Decree on prevention of air pollution caused by new large combustion plants. This decree sets emission standards for emissions of SO_2, NO_x and particulates from combustion of coal, oil or gas in combustion plants. The Royal Decree transposed the EC Directive of 1988 and applied the same values as those in the Directive (UN-ECE, 1998). Emission limits were tightened up on 1 January 1996 for the first time. The regions have to observe the federal government decree, but they have the competence to require stricter emission limits. For a comparison of emission limits in the Royal Decree between Vlarem 2 (Flanders) and Wallonia see the section on 'instruments'.

The regions have the responsibility for different environmental fields in 1980. However, it took some time before national policy plans appeared. Wallonia and Flanders adopted environmental policy plans in 1995 and 1997, respectively. In 1995 the Brussels government adopted the 'Regional Development Plan', which includes a chapter on the protection of the environment (OECD, 1998). The environmental policies of the regions will be described in the next section. Policies aimed at acidification and NO_x-emission reduction in industry will be described in more detail.

Flanders

From the second part of the eighties until the end of the nineties the Flemish strategy to abate air pollution developed in the direction of a structured environmental policy. One of the first steps was the use of emission limits in environmental permits. After that the environmental and exploitation permit were integrated into a single permit. In 1995 a decree on emission reduction of certain pollutants from combustion plants (Vlarem 2) came into force. From that moment on, similar emission limits were determined for the same type of combustion plants, instead of a case-to-case approach (Vankeerbergen and Muylle, 1995). The national environmental policy plan was formulated in 1997.

At the end of the eighties Flanders started an air remediation programme to abate air pollution. This programme had two objectives. The first objective was to gradually decrease air pollution caused by industry and the second objective was to decrease industrial emissions in zones with high-level air pollution. The Flemish government took the following measures to achieve the objectives:
- Emission limits were put into environmental permits. These emission limits were based on emission standards of the German 'TA Luft' and the EC Directive of 1988.
- Large companies had to draw up an emission inventory.

In zones with a high level of air pollution all companies contributing to this pollution would be systematically controlled (Lenssens, 1988).

Mina plan 2000 (1989)

The Mina plan 2000 appeared in 1989. On the one hand, this plan would provide an inventory of the state of the Flemish environment and nature areas, while, on the other, it would lay the foundation of a structural, renewed environmental policy for the nineties. Experiences in other policy fields and other countries would serve as a guideline for improvement of environmental policies. The renewed environmental policy would contain an integrated and systematic approach and better legislation.

Better legislation was necessary after the institutional reform. During institutional reform sectoral acts were amended and cancelled resulting in an inconveniently arranged legislation. One of the goals of the Mina plan was to institutionalise an inter-univeristy commission, which was to develop a proposal for co-ordinated and optimised Flemish environmental legislation. Flemish environmental legislation would be adapted on the basis of this proposal, which had to be ready in 1990. The commission also had to develop proposals for better enforcement (Mina plan 2000, 1989). The 'Bocken Commission', established at the end of the 1980s, reshaped the region's environmental legislation would conform to European legislation, have a cross-media approach and be consistent with a policy of sustainable development. A marked evolution of the Flemish environmental legislation occurred in the 1990s (OECD 1998). Despite the efforts of the 'Bocken Commission' little progress was achieved in enforcement. Vankeerbergen and Muylle (1995) mentioned that justice had played only a minor part in air pollution law enforcement till 1995.

Next to reconstruction of environmental policies and legislation, concrete measures were formulated for the abatement of air pollution:
- The Royal Decree of 28 June 1985 on the environmental permit would be implemented with priority.
- Permits on exploitation and discharge would be integrated into a single permit.
- Companies would be compelled to draw up an environmental-effect report and/or a security report. Environmental-effect reporting would be compulsory for various plants, including combustion plants with a capacity of at least 300 MW.

In the Mina plan 2000 the ratification of stricter emission limits for existing and new combustion plants was mentioned, but this intention was not translated into concrete measures. Afterwards, stricter emission limits were only set in 1995 (Vlarem 2). So, the ambition level was not raised for a long time. Summarising, it may be stated that the Mina-plan 2000 signified a start for reconstruction of the Flemish environmental policy and legislation after an uncertain period of institutional changes. However, a structured approach to air pollution abatement developed only after 1995 onward with the appearance of Vlarem 2 and Mina plan 2.

Mina plan 2 (1997)

The environmental policy plan (1997-2001) has been drawn up in accordance with the Decree on general stipulations on environmental policies (DABM). The environmental policy plan is part of a triptych, which consists of an environmental report, environmental policy plan and environmental year programme. The environmental report (MIRA) is a scientific document, which appears once in two years and describes, analyses and evaluates the state of the environment. The report also describes forward-looking scenarios, which take current policies and changes in policies into account. The environmental policy plan appears once in five years. The plan outlines a rough environmental policy for the next 20 years and contains action plans that the Flemish government wants to realise. The environmental year programme (MJP in Dutch) appears every year and is part of the implementation process. The programme indicates which part of the environmental policy plan will be implemented; the programme also contains a financial plan.

The environmental policy plan contains short and long-term objectives for the abatement of acidification. The long-term objective consisted of prevention and pushing back acid deposition so that no damage beyond repair occurs at ecosystems. The objective of the plan period consisted of reduction of acid deposition to a level of 2900 acid eq./ha in 2002. This is a reduction of 39 per cent compared to the 1990 level. Reduction in emissions of acid pollutants, including NO_x from industry, was necessary for reaching this objective.
General and sectoral NO_x-emission reduction targets were set for industry (Table 2). Since the reductions were based on the analysis of the possibilities per sector, an effort was made to divide the efforts among the companies equally. Emission limits had to be restricted to reach the NO_x-emission reductions in 2002 (action 19). Industry should use the Best Available Techniques (BAT) -in some cases - even faster than in current regulations. Maximal use of information at international level was necessary for this purpose. Shifts in time could take place on the basis of BAT studies and cost-effective analyses on Flemish and international level.

Table 2. NO_x-emissions reductions to be realised per sector in 2002

Industrial sectors	NO_x-emissions in 1990 (tonne/y)	NO_x-emissions that have to be realised in 2002 (tonne/y)	Percentage of NO_x-emission reduction compared to 1990
Chemistry	10,300	7200	30 %
Ferro	8052	7000	13 %
Non-ferro	1372	570	58 %
Other industry	8100	6885	15 %
Total	27,824	21,655	22 %

In the chemical, ferro and non-ferro sectors a limited number of sources were responsible for most of the emissions. For this reason target group policy was initiated in the policy plan. The accent moved towards care and prevention by companies, resulting in an active role of target groups in realising a number of actions drawn up by the authorities.

Wallonia

A rolling programme of state-of-the-environment reporting has been in place since 1993, with the publication each year of reports on selected topics to cover the whole environment over a period of four years. In 1995 Wallonia adopted the ‘Environment Plan for Sustainable Development’, which would require several sectoral plans. According to Walloon authorities, about 80 per cent of the actions included in the Environment Plan were still in progress at the end of 1997 and many actions would need to be completely reoriented (OECD, 1998).
With regard to NO_x-emission reductions, policies hinge primarily on the implementation of the EC Directive of 1984 (84/360/EEC) and the granting of operating permits to enterprises, who will establish operating conditions and individual standards on the basis of the General Regulations and Occupational Safety, and the German ‘TA Luft’ (Questionnaire UN-ECE, 2000).

Brussels

Although dealing with environmental issues became a regional responsibility in 1980, administrative competence in respect of various problems in the Brussels-Capital Region remained with the Federal government until 1989. With the creation of the Brussels Institute for Environmental Management (IBGE/BIM) in 1989, a five-year process of rationalisation began that resulted in the implementation of the institutional framework now in place. The Institute is the main actor on the environment set in the Brussels-Capital Region and publishes a state-of-the-environment report every two years. In March 1995, the regional government adopted a regional development plan that included a chapter on the protection of the environment. In 1998 work was under way at the Institute to develop a sustainable development strategy (OECD, 1998).

4.3.2.3 Instruments

Juridical instruments

The Royal Decree of Belgium came into force in 1987. The decree applies to combustion plants authorised after coming into force by the decree (3-6-1987) and with a thermal capacity of 50 MW and over. Emission limits set by the Royal Decree were determined on the basis of several factors, including date of authorisation and capacity of the plant and type of fuel used. With the aid of these factors, efforts to reduce NO_x-emissions were equally divided among companies. However, companies could easily meet the emission limits of the Royal Decree. This can be illustrated by showing that no low-NO_x techniques had to be purchased to meet the emission limits. Stricter emission limits were applied to almost all combustion plants authorised after 31 December 1995 (Appendix 5) (Royal Decree, 1987). Low-NO_x techniques had to be purchased to meet the stricter emission limits (Francois, 2002, pers. comm.). In Wallonia (Appendix 6) and Brussels the Royal Decree was almost literally implemented (UN-ECE, 1998; answers of Belgium to questionnaire 2000 of the UN-ECE, www.unece.org/env/lrtap).

Vlarem 2 of Flanders deviates a little from the Royal Decree of Belgium. Vlarem 2 came into force in 1995 in Flanders and includes NO_x-emission limits for combustion plants (Appendix 7). In the decree there is a difference between existing and new combustion plants. Combustion plants authorised before 1993 are called 'existing installations' and plants authorised after 1 January 1993 are called 'new installations'. However, discrepancy still exists about the boundaries of existing and new installations (www.mina.vlaanderen.be). With the coming into force of Vlarem 2 a few emission limits were tightened up for new combustion plants. These stricter emission limits also had to be met by existing combustion plants authorised between 1987 and 1993. A period of transition was foreseen for some sectors. For most of the existing installations (1987-1993) the emission limits would be valid from 1 January 1999. In 1995 emission limits came into force for installations authorised before 1987. This was the first time that emission limits were set for installations authorised before 1987 (answers of Belgium to questionnaire 2000 of the UN-ECE www.unece.org/env/lrtap). This is an important difference with the Royal Decree of Belgium and the EC Directive of 1988, both of which do not set emission limits for installations authorised before 1987. However, the emission limits of Vlarem 2 for combustion plants authorised before 1987 were easy to meet. No low-NO_x techniques had to be purchased to meet the emission limits (Francois, pers. comm. 2002). In 1996 emission limits of Vlarem 2 were tightened up to implement the stricter emission limits of the Royal Decree. Emission limits of the Royal Decree for coal were literally translated, and the emission limits for oil and gas were set as target values in Vlarem 2. Vlarem 2 set the same emission standards for oil and gas in 1996 as the EC Directive set in 2000. Since 1 January 2000 the emission limits of Vlarem 2 are almost the same as the emission limits of the EC Directive 2001/80/EC (answers of Belgium to the questionnaire 2000 of the UN-ECE www.unece.org/env/lrtap; Vlarem 2). On average, the Royal Decree of Belgium and Vlarem 2 do not differ much. The greatest difference in the Royal Decree between Belgium and Vlarem 2 is the emission limits for plants authorised before 1987, but these emission limits conformed more-or-less to existing emissions.

Summarising, it may be stated that, in general, Belgium has implemented the EC Directive of 1988. Only in the 1996-2000 period did Belgium have a higher ambition level than the EC Directive.

Permits

In the three regions, granting permits for air emissions forms part of the licensing of classified processes and installations. Permit procedures are carried out by provincial authorities on behalf of the regional government for activities classified as most harmful, and by local authorities for other harmful activities. Permits are based on emission limits, which differ between the three regions. The emission limits of Vlarem 2 became directly operative for companies after the coming into force of the decree. Emission limits included in permits granted before the date of commencement of Vlarem 2 were declared invalid (http://www.mina.vlaanderen.be). Compliance with Vlarem 2 is monitored during control and enforcement of permits. In Brussels and Wallonia there is a case-by-case approach based on internal guidelines (OECD, 1998). This implies that companies are responsible for compliance with the emission limits fixed in their permits. The differences between the regions can lead to differences in efforts of companies to reduce NO_x-emissions. The case-by-case approach in Wallonia and Brussels can also lead to differences in efforts of companies within the same region (UN-ECE).

Voluntary agreements

In 1994, Flanders adopted a decree that regulates voluntary agreements between industry groups and government agencies. The decree has been elaborated in the works of the ‘Bocken Commission’ (Misonne, 2000). The legal framework has been adopted in Flanders to promote greater openness and better compliance (OECD, 1998). Three agreements had been concluded in this framework till 2000. However, they do not concern reduction of NO_x-emissions in industry. In Flanders, no covenants have been signed on NO_x-emission reduction by industry and government agencies (Misonne, 2000).

In Wallonia and Brussels a legal framework for voluntary agreements between industry and authorities is absent. In Brussels, no covenants on NO_x-emission reduction have been signed. In Wallonia a ten-year voluntary agreement was signed between the Walloon government and the region's glass industry in 1995. The agreement was signed to reduce the industry's pollution in terms of energy use, discharges to water and emissions to air, including NO_x-emissions. The Walloon region committed itself to not tightening the emission limits fixed in the agreement before 2005 (OECD, 1998; Misonne, 2000).

Enforcement

In the national report of Belgium (1995) it was stated that in practice justice had played a minor part in air pollution law enforcement up to that moment. Legal actions related to air pollution were rare because of the confidentiality and the case-by-case approach of industrial licenses, as well as the difficulty of collecting substantial evidence. Furthermore, the fines and sanctions specified in law were generally considered to be very mild. The emission limits of Vlarem 2 were applied to all combustion plants, so a case-by-case approach has been out of the question in Flanders since 1995. This will improve enforcement. However, the intensity of enforcement did not increase in the investigated period because emission limits were easy to meet; as a result enforcement was unnecessary. Compliance with emission limits of 1996 requires application of techniques, and enforcement will be necessary in the future (Francois pers. comm., 2002).

The OECD has stated that control of compliance with permits of companies has greatly improved in Belgium in recent years. Nevertheless, the OECD has doubts about the adequacy of the inspection services in detecting irregularities and proposing appropriate remedies with respect to Belgium's many small and medium enterprises (OECD, 1998).

5. Linking policies to decomposition figures

The previous chapters considered the decomposition figures and policies of the Netherlands and Belgium. This section links NO_x-emission reduction policies to the determinant technique effect. The extent to which the instruments affected the course of the technique effect was also determined using the instrument characteristics developed by Van Wijk *et al.* (2001).

Instruments, like BEES and the Royal Decree of Belgium influence the NO_x-emissions at the level of installations and with that the reduction of NO_x-emissions of the total industry. Linking individual instruments to technique effect is hampered by the fact that this effect represents the combined result of several instruments. One of the instrument characteristics, imperativeness, helps to determine the effect of an individual instrument. Imperativeness indicates the degree to which an instrument limits the freedom of companies taking action (Van Wijk *et al.*, 2001). Policies will be implemented to a large extent where instruments limit the freedom of companies. Juridical instruments are more imperative than communicative instruments (Hoek *et al.*, 1998; Groeneveld *et al.*, 1996). For this reason juridical instruments have been intensively investigated.

5.1 Linking policies to the course of technique effect in industry in the Netherlands

The mix of instruments used to implement NO_x-emission reduction policies consists of the decree on emission limits of large combustion plants (BEES), and permits and covenants. BEES is the most imperative instrument, followed by permits and then covenants (Hoek *et al.*, 1998; Groeneveld *et al.*, 1996). BEES have had the greatest influence on industry when it comes to NO_x-emission reduction (Environmental Programme, 1997-2000; Poorter, 1996). It was with this knowledge that the relationship between BEES and the course of NO_x-emission was especially investigated.
BEES consists of BEESA (1987) and BEESB (1990). BEESA probably had a larger influence on the technique effect than BEESB, because BEESA set emission limits on large combustion plants, which are responsible for most of the total NO_x-emission (Kraaij, 2002, pers. comm.). Besides, BEESA set emission limits for a part of the industry that is easily accessible, while the target group of BEESB is less accessible. Medium and small-sized enterprises formed a bottleneck in achieving the objectives (NEPP 2, 1993), which indicates a small contribution of BEESB to the technique effect. BEESB will have contributed to the increase in technique effect, but the coming into force of BEESB is not visible on its own in the decomposition figure and the figure on technique effect (Figure 8 and 9). The effect of BEESA on technique effect will be discussed below.

Up to 1985 hardly any measures were taken to reduce NO_x-emissions in industry (Hoek *et al.*, 1998). Around 1990 a technique effect became visible in the decomposition figure (Figure 8). This effect is probably the result of BEESA coming into force in 1987. BEESA implemented the EC Directive of 1988 on the limitation of emissions of certain pollutants into the air from large combustion plants. Shortly afterwards, emission limits of BEESA were tightened up to become stricter than the emission limits of the EC Directive. In the beginning BEESA only set emission limits for new, large combustion plants, which may explain why the effect was only visible after three years. First, new combustion plants had to be built, and they had to purchase the newest techniques. In 1989 emission limits, which were easy to comply with, were set for existing combustion plants (Schijndel *et al.*, 1996). Harmelink *et* *al.* (1995) also indicate that a change in tendency is visible between realised energy use and NO_x-emission since 1991. This change in tendency is noted to be possibly caused by measures taken on combustion plants. However, significant effects of policies to abate emissions of combustion plants were not found in the study.

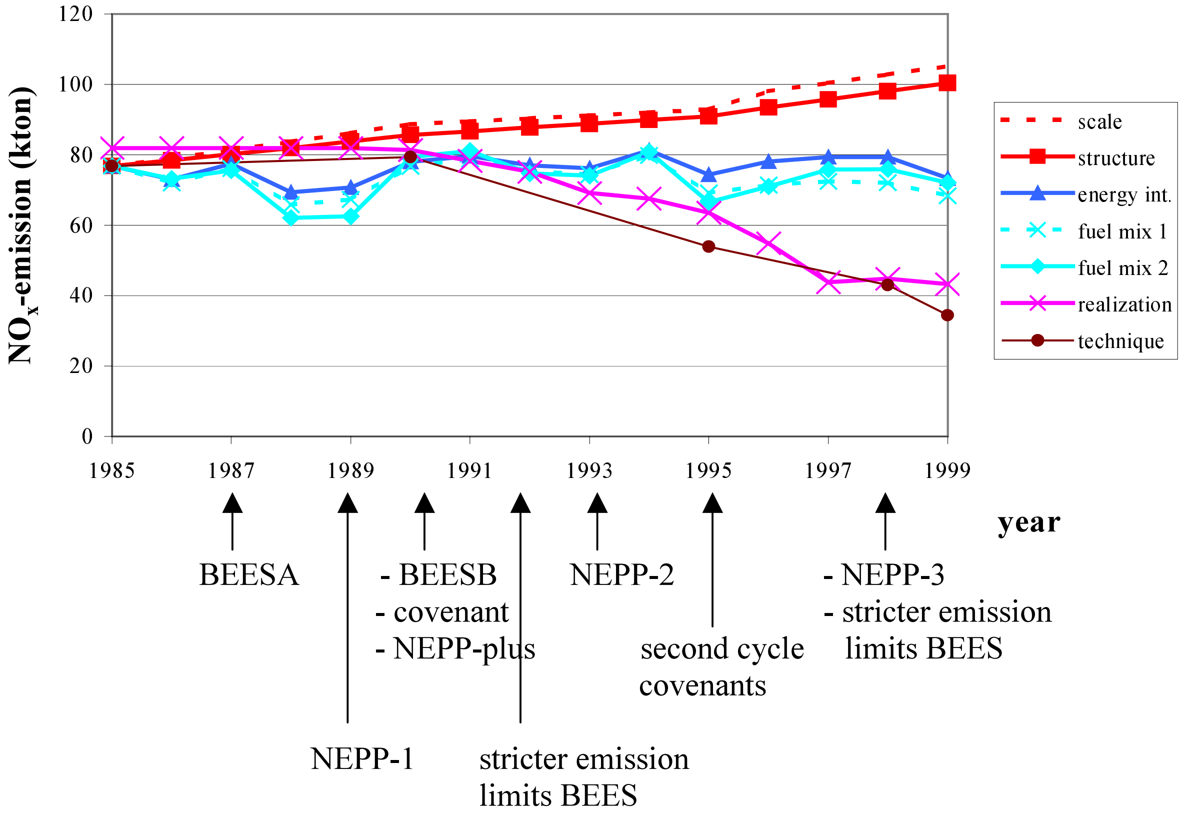

Figure 8. Link between policies and decomposition figure in the Netherlands.

Between 1990 and 1995 the technique effect gradually increased as a result of increase in the number of new combustion plants. However, between 1995 and 1997 a firm increase in technique effect was visible (Figure 8 and 9). This increase in technique effect is probably the result of strict emission limits for existing combustion plants coming into force in 1998. This was the first time that existing installations had to meet strict emission limits. An interim phase was introduced between 15 October 1992 and 1 January 1998 (Appendix 3). When existing combustion plants replaced their burners within this period, the new burners had to meet the tightened-up emission limits. By 1 January 1998 at the latest all existing combustion plants had to meet the stricter emission limits. This interim period was introduced to coincide replacement of burners from environmental point of view with replacement of burners from management point of view. Just as for existing plants, emission limits for new combustion plants were tightened up. So, the application of techniques to existing and new installations determine the development of technique effect in the interim period. This aspect will hamper distinction between effects of measures on existing plants and new plants.

There are several reasons to accept emission limits for existing plants as the major cause of the increase in the technique effect after 1995. Firstly, existing combustion plants probably still formed a substantial part of the total combustion plants at that time (large range).

Secondly, existing plants had to replace burners to meet the strict emission limits (high ambition level). Besides, the period within which existing combustion plants had to meet these emission limits was moderately short (high ambition level). Therefore the large range and high ambition level combined led to an increase in technique effect.

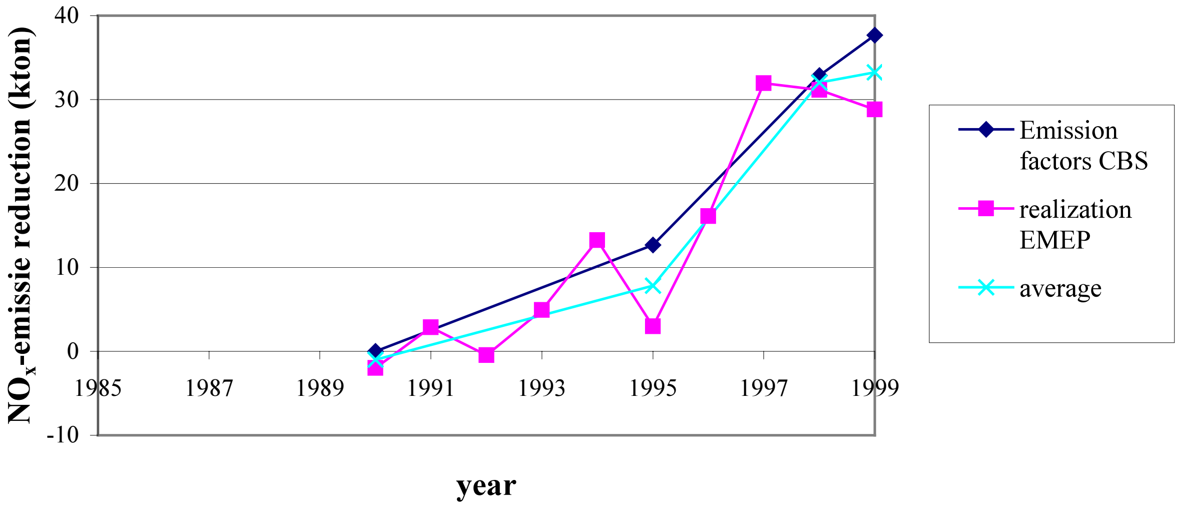

Figure 9. The development of the 'technique effect' determinant in the reduction of NO_x-emissions from industry in the Netherlands.

The Van Eck Marketing (1996) study 'NO_x-market analysis' and KW2 (2000) study 'Research in the records on the NO_x-emissions of different branches', investigated the development of the Netherlands' combustion plant park. The estimates on the development of the combustion plant park between 1992-2010 made by Van Eck Marketing (Appendix 1) gives an indication of how the combustion plant park developed in the 1987-1998 period. The development of the combustion plant park will differ according to period, but a rough comparison can be made. Focusing on furnaces and boilers, usually used in industry, it becomes clear that after eight years most of the combustion plant park still consists of the existing combustion plants. After 18 years approximately one-third of the combustion plant park will consist of existing combustion plants. In the KW2 (2000) study the real development of the installation park was measured, but the ratio of existing to new installations was not taken into account. The estimate made by Van Eck Marketing about the development of the total amount of combustion plants, clearly roughly corresponds to the KW2 measurements. With the aid of both studies one can assume that a large section (approximately one-half) of the combustion plant park consisted of existing installations (1987 and before) in 1998.

Another reason for the great impact of the emission limits for existing combustion plants on the course of the NO_x-emission was the necessary replacement of old burners by new ones in existing installations to meet the strict emission limits. Schijndel *et al.* (1996) expected that 60-70% of the existing boilers would need new burners to meet the stricter emission limits of 1998. Groeneveld *et al.* (1996) expected this increase in technique effect before the stricter emission limits of 1998 came into force.

Remarkable is the sharp increase after 1995, while the interim period lasted from 1992 to 1998. The reinforced increase in the technique effect may be the result either of the duration of the procedure for replacement of burners or of putting off the replacement of burners. If it is really a matter of delay, enforcement may have played a part (see section on enforcement). The stricter emission limits for new combustion plants may also have contributed to the increase in technique effect. However, this does not sound credible when looking at the decrease in technique effect after 1998 (Figs. 8 and 9).
After 1998 the increase in technique effect was reduced (Figs. 8 and 9). The interim period, in which existing plants had to meet the new emission limits, has passed and technique effect is only influenced by new installations as before 1992. The decrease in the ratio of existing to new installations is a gradual process, so technique effect will also gradually increase.

Permits and covenants

Permits and covenants are instruments that contribute to the compliance with BEES (VROM, 1992). Permits and covenants have probably influenced the course of technique effect, but direct linkages between permits and covenants and technique effect were not found. Hoek *et al.* (1998) state that a change in tendency concerning emission reduction did not appear as a result of covenants. Policy objectives have not been achieved more rapidly than previously decided.

Enforcement.

Besides the instrument characteristics ‘ambition level’ and ‘range’, enforcement may have played an important part in the increase of technique effect. Almost all enterprises that emit NO_x are supervised by provinces. In 1992, frequency of supervision on BEES by the provinces was not up to the mark. Besides, more than half the permits had not been controlled in five years or more and one-third had not been controlled in ten years or more. However, compliance with BEES was good at that time (VROM, 1992). Marsman and Van der Ploeg (1992) who investigated the compliance of ten combustion plants with BEES, also state that the compliance was good at that time. After 1992 the provinces increased their supervision of plants (Environmental Balance, 1998). In 1996, 96% of the permits was up to date. If compliance with BEES increased with better enforcement is not clear. The relationship between compliance and enforcement is weak (VROM, 1992). In contrast, enforcement is stated in the Environmental Balance of 1998 to be responsible for 20-30% of compliance. In Van Wijk *et al.* (2001) the assumption is made that the more frequent an inspector visits the company the higher the policy pressure will be.

It is difficult to draw conclusions from this information about the relationship between enforcement and compliance with BEES, and through this, the relationship with technique effect. It is clear that enforcement improved in the 1990s, but whether this improvement has led to better compliance with BEES can not be proven.

5.2 Linking policies to the course of technique effect in industry in Belgium

In the decomposition figures for Belgium and Flanders the technique effect is hardly visible. In the figure for Belgium it seems that technique effect becomes visible around 1990, but that this effect disappears in 1994 (Figure 10). It is impossible that technique effect disappears in four years, because it is very unlikely that applied techniques will be removed in such a short period. The effect may be the result of changes in methods of emission registration. In Flanders, a similar low NO_x-emission is visible in the decomposition figure in the beginning of the 1990s. In the report ‘Emissions to air 1980-2000’ of the Flemish Environment Administration (VMM) problems with the continuity of emission data are mentioned. In the period before 1992 companies registered their emissions on a voluntary basis, while emission registration was forced after 1992. This hampers comparison of the period before and after 1992.

So it is assumed that in Belgium and Flanders, in turn, that a technique effect has not appeared. The absence of technique effect is probably the result of easily achievable emission limits for combustion plants authorised before 1996. These emission limits were achievable without the application of NO_x-reducing techniques. That the emission limits were achievable without the application of NO_x-reducing techniques is still remarkable, considering that the emission limits had been adopted by the EC Directive of 1988. Here, it is stated that emission limits are based on the best available techniques not exceeding excessive costs. In 1996 Belgian emission limits were tightened up with the result that application of NO_x-reducing techniques was necessary for compliance with these limits. However, combustion plants authorised after 1996 formed a minority of the total combustion plant park of Belgium in the period investigated (1985-1999). The technique effect is expected to make its appearance in the future because of the stricter emission limits of 1996.

For the appearance of technique effect, compliance with emission limits is just as important as strict emission limits. Compliance with emission limits can be supported by permits, covenants and enforcement. In Belgium enforcement of emission limits has, so far, not been very intensive. On the one hand, enforcement of emission limits was unnecessary. On the other hand, as earlier mentioned in section 4.3.2.3 enforcement was hampered by several factors. Industrial licenses were confidential and may vary from case to case. The instrument characteristics ‘publicity’ and ‘monitorability’ of permits were developed in a way as to hamper enforcement. Enforcement of case-by-case permits is time-consuming and may be confusing. In Wallonia and Brussels permits were granted case-by-case (Vankeerbergen and Muylle, 1995). The coming into force of Vlarem 2 in Flanders has led to equal emission limits for simultaneous installations, so a case-by-case approach was no longer applied. This facilitates enforcement of emission limits. Furthermore, the fines and sanctions specified in the law were generally considered to be very mild. This indicates that the instrument characteristic ‘legal force’ was too weak.

Covenants can also improve compliance with emission limits. However, in Belgium covenants were hardly ever set down for NO_x-emission reduction. One may wonder why emission limits were not frequently tightened up, enforcement developed insufficiently and why a reliable emission registration was a long time coming. One of the most important reasons is the institutional reform of Belgium, which resulted in a long period of uncertainty (OECD, 1998).

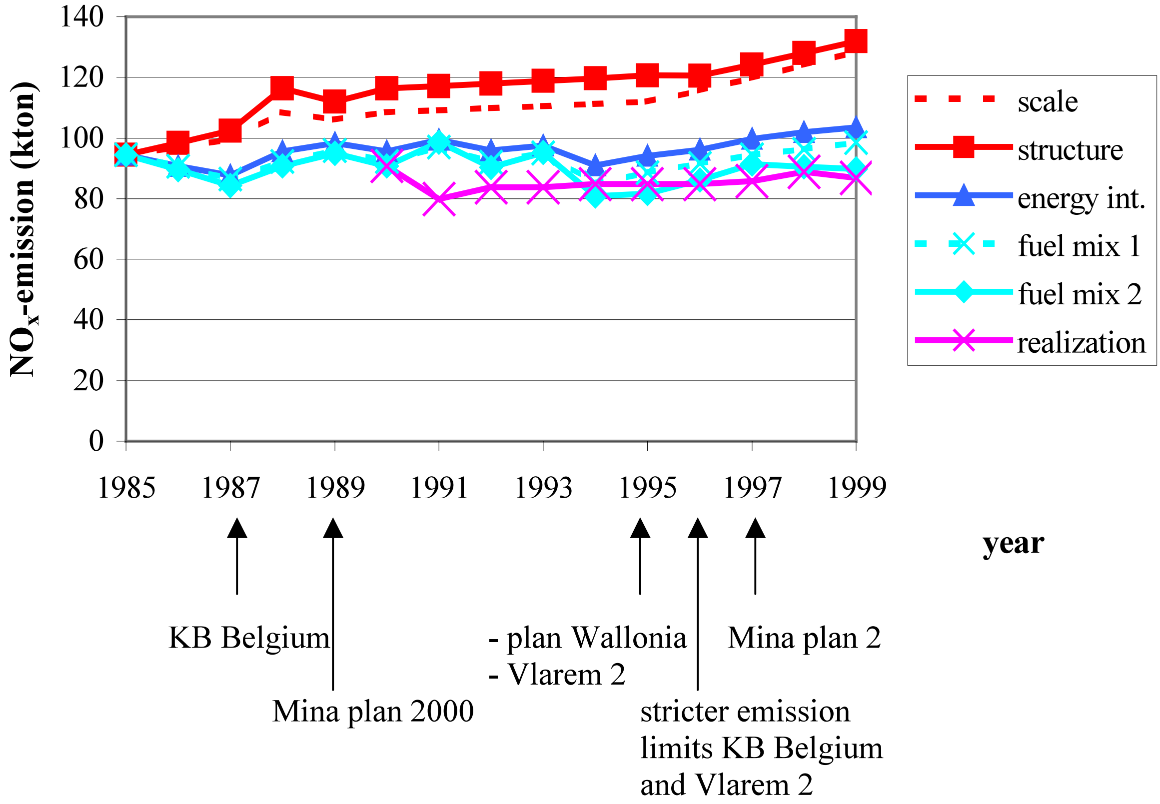

Figure 10. Link between policies and the decomposition figure in Belgium.

5.3 Differences in links between policies and course of technique effect of the Netherlands and Belgium

The technique effect developed in the Netherlands after 1990. A few links were found between policies and development of technique effect. In Belgium the technique effect failed to occur, which hampered the linkage of policies to the decomposition figure. Different factors can have led to the absence of technique effect. It is hard to prove which factors are most responsible for the differences in development of technique effect between the countries because a lot of variables vary simultaneously. The factors considered to link policies to technique effect form the base for the determination of the most important differences between the development of technique effect in both countries.

All in all the ambition level and range of emission limits of the Netherlands were higher than in Belgium during the period investigated. Differences in ambition level of emission limits is one of the most important factors for explaining differences in technique effect between the countries. In Belgium, emission limits for combustion plants authorised before 1996 could be met without applying low-NO_x techniques. In the Netherlands emission limits could only be met with the application of low-NO_x techniques. Combustion plants authorised after 1996 have to apply new techniques to meet the emission limits. These limits have not yet led to the appearance of a technique effect because the number of combustion plants authorised after 1996 is still small.

The range of instruments also contributed to differences in development of the technique effect. The range in the Netherlands was larger than in Belgium for capacity and date of authorisation of combustion plants. Emission limits of the Netherlands were set for all combustion plants independent of capacity, while in Belgium emission limits were only applied to combustion plants with a capacity of 50 MW and over. However, in the Netherlands small- and medium-sized enterprises formed the bottleneck in implementing NO_x-reduction policies (NEPP-2). So, range has not played a major part in this way. Range, with respect to date of authorisation of combustion plants, contributed to differences in the technique effect. In the Netherlands, the range was extended in 1989 by setting emission limits for plants authorised before 1987. In 1995, Vlarem 2 set also emission limits for plants authorised before 1987. In the rest of Belgium emission limits still do not exist for combustion plants authorised before 1987. The strict emission limits for existing plants, which came into force between 1992 and 1998 led to a firm increase in technique effect in the Netherlands.

Enforcement also differs between the countries, but this instrument characteristic was probably not responsible to a large extent for differences in the technique effect. In Belgium emission limits were easy achievable and by this means enforcement did not play an important part in compliance. In the Netherlands compliance with BEES was influenced by enforcement and voluntary agreements, both of which developed during the 1990s. The report of VROM (1992a) stated that compliance with BEES was good at that time.

In summary, differences in NO_x-emission limits (ambition level) are probably the major factor for differences in technique effect. Besides, range, especially with respect to date of authorisation, also contributed to differences in technique effect. Enforcement probably contributed to the appearance of technique effect in the Netherlands.

6. Conclusions

Previous chapters have described the case study on reduction of NO_X-emissions from combustion plants in industry in the Netherlands and Belgium. This case study provided insight into the causes of the different policy effects of the Netherlands and Belgium. However, what is the value of the linkages between policies and decomposition figures, in this policy analysis?

- **Decomposition figures can direct policy analysis.**

The combination policy-decomposition figures have a bilateral function. On the one hand, decomposition figures confirm expected changes in technique effect on the basis of policy analysis and, in doing so, underpin policy analysis. In the case study a technique effect was expected as a result of BEESA coming into force in the Netherlands in 1987. The appearance of technique effect in 1990 indicates that the coming into force of BEESA actually resulted in a technique effect. On the other hand, changes in decomposition figures indicate changes in policies. The substantial increase in technique effect in the Netherlands between 1995 and 1997 pointed to an important policy event. After investigation, this measure appeared as strict emission limits for existing installations. In this way decomposition figures can direct policy analysis.

The interaction between decomposition figures and policy analysis can sometimes lead to discrepancies that may also direct policy analysis. An example is the absence of technique effect in Belgium, while appearance of technique effect was expected through policy analysis. This discrepancy appeared to be the result of easy achievable emission standards. So, use of decomposition figures can also push policy analysis into another direction.

- **Linking policies to decomposition figures requires details**

Linkages between policies and decomposition figures can only be found with detailed research. In the course of time instruments go through changes that can affect the emission course. These changes have to be precisely investigated to estimate the effect of the instrument on the emission course. The juridical instruments of the case study, for example, went through various changes. The changes in emission limits were presented in overviews to make clear the development of the instruments. Changes in instruments seemed to be of importance for the explanation of changes in emission course. The instrument characteristics presented in Van Wijk *et al.* (2001) have provided structure to the detailed investigations of instruments.

The development of the decomposition figures also requires many details to represent changes in policies. When decomposition figures are too rough policy effects will be smoothed down and links can not be found between policies and decomposition figures. These detailed studies are time-consuming. It also has to be taken into account that details will not always be available.

- **Details conflict with high aggregation level.**

The use of the combination policy-decomposition figures in international policy analysis requires both broadwise and in-depth investigation. The determination of policy effects requires in-depth studies. Policy effects were expressed through linkages between policies and decomposition figures in the case study. The linkages found in the in-depth studies were used in the comparisons between the Netherlands and Belgium. The broad-based and in-depth studies take a lot of time, so if more countries are involved in the policy analysis this method will be very time-consuming.

The use of decomposition figures alone also gives a fair idea about the NO_x-emission reduction policies developed and are less time-consuming. In the case study, technique effect was well-developed in the Netherlands and absent in Belgium. This already provided considerable information about the differences in NO_x-emission reduction policies of the two countries. Where policies were linked to the decomposition figures, getting clear causes for the differences happened more precisely, but this required much more effort. The ratio of efforts to results is much higher when the combination policy-decomposition figures is used than when decomposition figures are used alone. So, the usefulness of the combination policy-decomposition figures is doubtful for international policy analysis.

- **Linkage between individual instruments and decomposition figure is difficult.**

Courses of determinants are the result of combining several instruments. Individual effects of instruments will be better perceptible when the instruments are imperative and have a large range. In the case study imperative instruments, in particular, were linked to the determinant technique effect. Other instruments also influence the effect of the determinant, but these effects can not be individually perceived. Nevertheless, effects of less imperative instruments have to be taken into account in international policy analysis, because these instruments can influence the effect of the imperative instruments. Voluntary agreements, for example, can increase the social basis of BEES and through this the effect of BEES.

- **Availability of data is important.**

Data necessary for the development of decomposition figures have to meet a number of criteria. First, data have to be internationally comparable. In the case study data were obtained for international organisations that determine the national data in the same manner. Second, data have to be detailed enough. Gross product of industrial sectors and energy statistics are examples of detailed data. In the decomposition figure for Flanders this determinant was left out, because data were not in stock. Another criterion that has to be met by data is consistency in time. Methods for the determination of data change with time. In the course of time, methods have been adapted to approach reality. Data of past years are often calculated with the new methods, but the number of years is limited. This hampers carrying out of investigations that focus on long periods. The emission registration of Belgium is a good example of inconsistency in time.

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Appendices

Appendix 1

Ratio existing/new in 2000	Existing (1992)	New (after 1992)
Gas turbines	88 (58%)	64 (42%)
Furnaces (>10 MW)	135 (66%)	65 (33%)
Boilers (>10 MW)	*	*
Ratio existing/new in 2010		
Gas turbines	36 (18%)	165 (82%)
Furnaces (>10 MW)	84 (35%)	159 (65%)
Boilers (>10 MW)	*	*

- Boilers (>10MW): number of boilers decreased in period 1990-2010. Number of boilers in industry: 377 in 1992, 274 in 2000 and 163 in 2010. A large number of the 1992 installations will not be replaced, so almost all installations in 2000 and 2010 will be still from1992.

Appendix 2. Overview of the emission limits of the EC Directive of 1988.

	7-7-87	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	1-1-00
unit (mg/m^3)														
new installations														
(authorized after 7-7-1987)														
solid														
50-100 MW	650													
														400
100-300 MW	650													
														300
> 300 MW	650													
														200
liquid														
50-100 MW	450													
														400
< 300 MW	450													
														300
> 300 MW	450													
														200
gaseous														
< 300 MW	350													
														150
> 300 MW	350													
														100
other gasses	350													
														200

Appendix 3. Overview of the emission limits of BEESA (1987) for the Netherlands.

	29-5-87	1-8-88	1-1-89	1-1-90	15-9-91	15-10-92	1993	1-1-94	1995	1996	1997	1-1-98	1-5-98	1999	2000
unit (mg/m^3)	phase 1	phase 2				phase 3		phase4							
new installaties															
(authorized after 29-5-1987)															
solid															
< 300MW	650														
		500													
						200									
								100							
> 300 MW	400														
			300												
				200											
liquid															
combustion plants	450														
		300													
						150									
													120		
furnaces	450														
					300										
						200									
													120		
gaseous															
combustion plants	350														
		200													
						100-200 (1)									
													70		
furnaces	350														
					150-200 (1)										
													80-140 (1)		
existing installations															
(authorized before 29-5-1987)															
solid															
20-300 MW						650 (2)									
> 300MW			1000/1100												
						650 (2)									
liquid			700												
						200/400 (2)									
gaseous			500												
						150 (2)									

(1) Value of emission limit depends of type of gaseous fuel and type of installation.

(2) Emission limit has to be met by installations of which the burners are replaced in the period 1992-1998. Emission limit has to be met in 1998 at the latest.

Appendix 4. Overview of emission limits of BEESB (1990) for the Netherlands.

	1-8-90	1991	15-10-92	1993	1-1-94	1995	1996	1997	1-1-98	1-5-98	1999	2000
unit (mg/m^3)												
new installations												
(authorized after 1-8-1990)												
solid	500											
			200									
					100							
liquid	300											
			150									
										120		
gaseous	200											
			100									
										70		
existing installations												
(authorized before 1-8-1990)												
solid												
> 20 MW			650 (1)									
liquid			700									
			200/400 (1,2)									
gaseous			500									
			150 (1,2)									
										70 (3)		

(1) Emission limit is applied to installations of which burners are replaced in the period 15-10-1992 and 1-1-1998. Burners have to be replaced before the first of Januari 1998 at the latest.

(2) First emission limit is applied to gas oil and the second emission limit is applied to fuel oil.

(3) Emission limit is applied to boilers with a capacity of < 10 MW the moment burners are replaced.

Appendix 5. Overview of the emission limits of the Decree of Belgium (1987).

	3-6-87	1988	1989	1990	1991	1992	19-11-93	1994	1995	1-1-96	1997	1998	1999	2000
unit mg/m^3														
new installations														
(authorized after 3-6-87)														
solid														
50-100 MW	800													
							650/800(1)							
										400				
100-300 MW	800													
							650/800(1)							
										200				
> 300 MW	650													
										200				
liquid	450													
										150				
gaseous														
except blast furnace gasses	350													
										100				
blast furnace gasses	350													
	(1) First emission limit is applied to solid fules in general, second emission limit is applied to fuels with a content of < 10% volatiles.													

Appendix 6. Overview of the emission limits applied to installations of Wallonia.

	3-6-87	1988	1989	1990	1991	1992	1993	1994	1995	1-1-96	1997	1998	1999	2000
unit mg/m^3	KB Belgium													
new installations														
(authorized after 3-6-87)														
solid														
<100 MW	800													
										400				
>100 MW	650													
										200				
liquid	450													
										150				
gaseous														
except blast furnace gasses	350													
										100				
blast furnace gasses	350													

Appendix 7. Overview of the emission limits appliedto installations of Flanders

	3-6-87	1988	1989	1990	1991	1992	1993	1994	1-8-95	1-1-96	1997	1998	1999	1-1-00
unit mg/m^3	KB Belgium								VLAREM					
new installations														
(authorized after 3-6-1987)														
solid														
50-100 MW	800													
									650 (1)					
										400				
>100 MW	800													
									650 (1)					
										200				
>300 MW	650													
										200				
liquid														
50-100 MW	450													
										400				
100-300 MW	450													
										400				
														300
>300 MW	450													
									200 (2)					
gaseous														
blast-furnace gasses	350													
natural gas/bio gas														
50-300 MW	350													
										150				
>300 MW	350													
										100				
other gasses	350													
										200				
existing installations														
(authorized before 3-6-87)														
solid									950					
liquid									575					
gaseous									425					

(1) Emission limit applied to installations authorized between 3-6-87 and 31-12-95.
(2) Emission limit applied to installations authorized after 3-6-87.