CERNA, Centre d'économie industrielle
Ecole Nationale Supérieure des Mines de Paris

60, bld St Michel - 75272 Paris cedex 06
Tel.: (33) 01 40 51 90 91
Fax: (33) 01 44 07 10 46
cerna@paris.ensmp.fr

Research Paper

2000-B-4

Adjustments in the Dutch electricity producing sector in the context of the European Directive 88/609/EEC

A case study on national implementation, environmental effectiveness, allocative efficiency, productive efficiency and administrative costs

Kris Lulofs
University of Twente
Center for Clean Technology and Environmental Policy

PO box 217 - 7500 AE Enschede
tel: (00)31 53 4894539
k.r.d.lulofs@cstm.utwente.nl

European Project IMPOL -
The Implementation of EU Environmental Policies: Efficiency Issues

Contents

Foreword

This report is an outcome of *The Implementation of EU Environmental Policies: Efficiency Issues* (IMPOL) project. The IMPOL project involved four research institutes (CERNA, Ecole des Mines de Paris, SPRU – Science and Technology Policy Research University of Sussex, CSTM, University of Twente, UFZ Leipzig-Halle) and was funded by the European Commission's DGXII under its Environment and Climate Programme (contract ENV4-CT97-0569) and national institutions (including ADEME, the French environmental agency). As its name suggests, the project concerned the implementation of EU environmental legislation. It sought to answer questions such as:

1. Does implementation result in the attainment of the environmental goals set out in EU Directives?

2. How does implementation affect the cost effectiveness of a particular environmental policy?

The core of the project consisted of the *ex post* evaluation of the implementation outcomes of selected pieces of EU legislation in four Member States (France, Germany, the Netherlands and the United Kingdom). Three cases studies were evaluated: Directive regulating emissions from existing domestic waste incinerators (89/429); the Directive on emissions of SO_2 and NO_X from Large Combustion Plants (88/609); and, the Council Regulation on the Eco-Management and Audit Scheme (1863/93) or EMAS.

IMPOL research reports are available at http://www.cerna.ensmp.fr/Progeuropeens/IMPOL. For further information, please contact:

Matthieu Glachant

CERNA - Ecole des Mines de Paris

60, boulevard Saint-Michel
F- 75272 Paris cedex 06

Tel: +33 1 40 51 90 91
Fax: +33 1 44 07 10 46
glachant@cerna.ensmp.fr

1. Introduction

Within the context of the IMPOL project several fields of European environmental policy are studied on aspects as national implementation and environmental and efficiency outcomes. For the IMPOL project a case study was done on the transformation of the Dutch electricity sector in the context of the European Directive 88/609/EEC. The indicators used in this report for environmental effectiveness, allocative efficiency, productive efficiency and administrative costs were chosen in line with a coordinating document (Eames, 1999).

The European Directive 88/609/EEC regulates Large Combustion Plants on their SO2 and Nox emissions. These emissions are relevant for air quality and for the acidification problem. In the empirical part of this report emphasis is laid on the power plants as a specific sub-group of the large combustion plants.

The report starts in chapter 2 with a description of the Dutch policy on acidification and regulation that existed when 88/609/EEC was issued. This way it is clarified that the formal implementation of the European Directive was done in the Netherlands with very little effort. In section 2.4 some major information on the structure of the electricity production sector is given as well as some insights into developments. In section 2.5 details on a covenant to reduce emissions from power plants is given. The electricity sector and the government agreed upon this document as a binding agenda for change. In section 2.6 information on monitoring and enforcement is given.

In chapter 3, the environmental outcomes are discussed. First the emissions of all large combustion plants are presented in time series. Within the IMPOL research-team the decision was taken to concentrate on the SO_2 emissions of power plants. Therefor, secondly the SO_2 emissions of the power plants and the individual power plants are presented. This opens the possibility for an analysis of the found decrease of SO_2 emissions. In section 3.3 the likely causes and their weight are assessed. In section 3.5 some conclusions about environmental effectiveness are formulated.

In chapter 4 the allocative efficiency of adjustments is elaborated. First the SO2 abatement patterns of individual plants are presented, followed by the way the costs were distributed in the electricity sector. Finally the costs for individual measures and plants are elaborated.

In chapter 5 the freedom to choose between alternatives to meet the SO2 demands is discussed. Although there was a covenant with SO2 and Nox implemented in the Netherlands with targets on the aggregate level of the sector, the actual freedom to choose, the allocative efficiency was seriously limited by existing regulation. In chapter 6 an assessment of administrative costs is given. Finally in chapter 7 some summarizing conclusions are drawn.

2. Implementing directive 88/609/EEC in the Netherlands

The implementation of EU directive 88/609/EEC in the Netherlands was done with very little effort. In order to understand this, the strategic position of the Netherlands in international games, the policy on acidification policy and the legislation in use for Large Combustion Plants since 1987 has to be understood. This will be explained in section 2.1. In section 2.2 the prospects on the acidification policy are described. The formal implementation of the European Directive 88/609/EEC is described in section 2.3. In section 2.4 the analysis is focussed on the Dutch covenant upon which the government and the electricity sector agreed upon. This covenant aims at lowering the emissions of electricity plants. The covenant can be interpreted, but certainly not causal linked to, the reduction objectives/emission reduction plans that are mentioned in 88/906/EEC.

2.1. Dutch policy and legislation existing when 88/609/EEC was issued

Policy on acidification

Dutch policy on acidification started in the late seventies. This policy was not only driven by arguments to fight acidification, it was preliminary launched as an instrument to control and improve air-quality. Both elements are of course interrelated. Already in 1983, in the Indicative Multi-Year Program Air Pollution 1985-1986, targets for the year 2000 for the emissions of SO2, Nox and NH3 and VOS were formulated (Second Chamber of Parliament, 1985-1989, 18605 nrs 1-2). In 1987 there was regulation issued that set limits on the SO2 and Nox emissions of large combustion plants. For new power plants SO2 abatement equipment became unavoidable and also existing plants knew that there life-span was limited. After 1985 "environment" and especially "acidification" became empathic subjects in the Netherlands, both in public opinion and in politics. Information became available about the serious harm of the acidification problem. Signals from Germany about massive “Waldsterben” were combined with national signals. A substantial research program on the processes and effects of acidification was called for and started: the Additional Program Acidification Research.

The years 1985-1987 were the period in which the World-commission on Environment and Development (widely known as the “Brundtland Commission”) prepared the report “Our common future" (1987). Parallel an in depth-study was done on the Dutch situation and the outcomes were as pessimistic as they became influential. This comprehensive inventory with explorations for the future was done by the National Institute of Public Health and the Environment (In dutch: Rijksinstituut voor de Volksgezondheid en Milieuhygiene, in short: RIVM). The RIVM studies and reports on the state of the Dutch environment. The report of the RIVM was published in 1988 and had huge impacts. Environmental affairs became real issues in politics and in the public opinion. The report can be qualified as the most important driver for the innovative and far reaching first integral National Environmental Plan that was issued on May, 25 th 1989. The plan that was issues by four Ministers: The Ministry of Housing, Physical Planning and Environmental affairs, the Ministry of Economic Affairs, the Ministry of Agriculture and Fishery and the Ministry of Traffic and Water Management were involved. The focus was shifted from a sector approach (water, air, surface) to an integral approach. The target group policy was introduced. With target groups distinguished such as the industry, the power sector, agriculture, consumers, waste-sector and traffic. A really ambitious agenda for change was formulated in the first National Environmental Plan.

How big "environment" as an issue was at that time can be understood even better when we go a bit into political developments at that time. The Minister of Environment did present the first National Environmental Plan as an outgoing minister. The cabinet fell while anticipating the first National Environmental Plan. In order to push-back traffic and pollution by traffic, the tax regime should be changed. Traveling expenses for commuter traffic were going to be made less tax-deductible. The members of parliament did not support this initiative of the cabinet. The cabinet was "conservative/Christian-liberal" coalition. The minister of Environment was also a liberal.

Elections were held and the electoral contest was dominated by discussions how to adopt to sustainability in socio-economic systems. The liberal party did suffer for its little environmental friendly policy. The new cabinet was a coalition of the conservative Christian party and labor party. The formation of the cabinet was under constant time pressure. The general thought was that "there was not time to spill given the important issues at stake that had to be taken care of". The impact of the study of the National Institute of Public Health and the Environment was later once again recognized: such kind of study is know done every 2 years.

In the first National Environmental Plan the official goal of the acidification policy was to reduce acid emissions by 70-80% in 2000 in order to preserve woods and nature reserves. Recognized is that because of efforts of industry and power plants the SO2 emissions are decreasing since 1980. Nevertheless power plants had to reduce from 65 kilotons/year in 1985 to 30 kilotons SO2/year in 2000. Industry had to reduce from 69 kilotons/year in

1985 to 15 kilotons /year in 2000. Refineries had to reduce from 95 kilotons/year in 1985 to 36 kilotons /year in 2000. Traffic and households had to reduce from 47 kilotons/year in 1985 to 24 kilotons /year in 2000. For the period after 2000 an additional effort is announced.

This policy document was followed by the more concrete National Plan for Fighting Acidification (Second Chamber of Parliament, 1988-1989, 18225, nr.31). Targets for 2000 and 2010 were formulated both quality targets and emission targets. First the emission targets were formulated for each target group, par example the agriculture sector, traffic, industry, refineries, electricity-plants. The environmental activists, the literature and the consultation councils thought the tempo of emission-abatement was still too slow. Still deposition of acidification-equivalents decreased between 1980 and 1995, a full 73% as SO2 is at stake, 16% when NOx is at stake and 25% when NH3 is at stake (Keizer, 1997).

Because the Dutch National Plan for Fighting Acidification (TK 1988-1989) required a decrease of 80 % for the year 2000, compared to the SO2 emissions of 1980, there are no further obligations within the international protocols that the Netherlands subscribed: in 1985 the Netherlands signed the Helsinki protocol which required a 30% decrease of SO2 (compared to 1980). The United Kingdom, the United Nations of America and the South-European countries did not sign. Developments in several countries were more positive than expected and that made the so-called Oslo-Protocol of June, 14th 1994 attainable. The reduction percentages are in table 1:

Table 1: % reductions, compared to 1980

	2000	2005	2010
Netherlands	77		
Germany	83	87	
France	74	72	79
United Kingdom	50	70	80

Source: V.G. Keizer, 1997

Of course the Directive 88/609/EEC was, for the EU Member States, an important step in between both protocols. Nevertheless this should for the Netherlands not to be perceived as an argument that any abatement is caused by the European Directive or by the Oslo protocol. It was indeed the Netherlands that was one of the driving forces in the international acidification-policy, that led to a situation that also other countries are required to stricter emission abatement. The fact that Dutch government is motivated to press for a more progressive policy on acidification can easily be understood by the fact that about 75% of the acid deposition in the Netherlands is caused by foreign countries (RIVM, Milieubalans, 1988).

Dutch legislation when EU directive 88/609/EEC was issued

An Important instrument in order to implement the policy on acidification were limits set by the Dutch Act on Air Pollution (in short: WLV). Under this legal regime in 1987 a directive on emissions from large combustion plants came into force as predecessor of guidelines for permitting authorities. In short this was called “Bees WLV” (Stb. 1987, 1987). This directive applied on combustion plants with a thermal capacity of more than 75 MW. For smaller combustion plants there was the Bees HW. The mean reason for this split up was that the competent authorities were different. Large combustion plants had to meet the requirements of a sector law that controlled air-pollution (Bees WLV). The competent authorities for the permits and monitoring and enforcement are the provinces. For smaller combustion plants the competent authorities were, in most cases, municipalities (Bees HW).

2.2. Prospects on the acidification policy

Changes in the economic structure of the electricity sector that will be discussed in section 2.4, led to a strong focus on costs within the sector nowadays. The raised national competition and the strongly raised international competition make this inescapable. Being a front runner on environmental demands makes companies often less competitive. The electricity sector already meets the demands for 2010 on SO2, on Nox a lot still has to be done. Voluntary agreement on this is not within reach. The government nowadays thinks about a unified approach for refineries, industry and power plants. Thoughts are about a SO2 and NOx funds, being the emphasis on Nox. A certain level of marginal abatement costs probably will be fixed. Thoughts are about 5000 guilders/ton SO2 abated and 10.000 guilders/ton Nox. Companies that are above this level get money out of the funds. Companies that do not demonstrate that they have reached this level of abatement have to pay. Still these thoughts are in the phase of policy making. A lot of implementation problems still have to be solved, final decisions are not made yet. On aggregate level the target for acidification (1400 acid equivalents in 2010) will not be reached easily. The expectations are therefor ongoing efforts both national as in the international arena.

2.3. Formal integration of EU 88/609/EEC

In order to meet all the formal requirements of EU 88/609/EEC, Bees WLV was adjusted July 5th, 1991 (Stb. 354). Important to note is that the Dutch government used their competence to raise the ambition level and, with other words, lower the emission standards as set by the Directive 88/609/EEC. This was done in order to reach for the goals of the

Dutch acidification policy that already was structured. The countries of comparison according to the responsible people at the Dutch Ministry were Germany and the United States of America. The developments at the level of the European Union were of no importance for the core of policy and legislation concerning Large Combustion Plants.

Figure 2: Emission limits Large Combustion Plants in the Netherlands by Bees WLV 1991 (des. = desulferication)

New plants 300 MW or more	**SO2 mg/m3**	**Nox mg/m3**	**Dust mg/m3**
Coal	400 (des. 85%)	650 (permitted before 1/8/88) 400 (permitted after 1/8/88)	50 (20-50)
Oil	400 (des. 85%)	450 (permitted before 1/8/88) 300 (permitted after 1/8/88)	
Gas	35	350 (permitted before 1/8/88) 200 (permitted after 1/8/88)	
New plants less than 300 MW	**SO2 mg/m3**	**Nox mg/m3**	**Dust mg/m3**
Coal	700	650 (permitted before 1/8/88) 500 (permitted after 1/8/88)	50 (20-50)
Oil	1700	450 (permitted before 1/8/88) 300 (permitted after 1/8/88)	
Gas	35	350 (permitted before 1/8/88) 200 (permitted after 1/8/88)	
Existing plants 300 MW or more	**SO2 mg/m3**	**Nox mg/m3**	**Dust mg/m3**
Coal	400 (after 1/12/89) for plants in function after 1994 or 1999, des. 85%, otherwise max S 0,8% for plants until 1994 or 1999	1000 (after 1/12/89) for plants with a life of more than 10000 hours, (800-1000)	
Oil	400 (after 1/12/89) for plants in function after 1994, others: 1700 mg/m3	700 (after 1/12/89) with a life expectancy of more than10000 hours (450-700)	
Gas	As new plants (after 1/1/88)	500 for plants with a life of more(after 1/1/89)	As new plants (after 1/12/89)
Existing plants less than 300 MW	**SO2 mg/m3**	**Nox mg/m3**	**Dust mg/m3**
Coal	max. 0,8% S in electricity plant		
Oil	1700 (after 1/6/87)	700 (after 1/12/89) with a life of more than 10000 hours (450-700)	
Gas	As new plants (after 1/1/88)	500 (after 1/1/89) for plants with a life of more than 10000 hours (500-450)	As new plants (after 1/12/89)

There were however a few technicalities changed in Bees WLV 1987 in order to meet the formal requirements of EU 88/609/EEC: At the moment that the Directive 88/609 was translated into Dutch legislation the difference between large and small was adjusted towards the EEC Directive: 50 MW. Large is defined as larger than 50 MW (thermal capacity). Different from the EEC Directive, emission limits are divided in two categories: 50 - 300 MW and larger than 300 MW. The difference between `new' and `existing' combustion plants is used. But what a `new' plant is, is not defined. `New' is the plant that is not `existing'. Existing combustion plants are those plants that are permitted before May, 29th, 1987. `New' is a combustion plant when it is permitted on or after May, 29th, 1987 or when the burners and ovens are renewed. The date is a bit different from July, 1th, 1987 that is given in the 88/609/EEC. The difference is minor.

A lot of standards that are required by the Bees WLV 1987 are stricter, so more ambitious, than the emission requirements that are prescribed by the directive 88/609/EEC. So it wasn't necessary to adjust most emission requirements in Bees WLV. There is one exception: new coal-fuelled combustion plants, that were permitted before August 1st, 1988, were not allowed to emit more than 800 mg NO_x/m3 according to Bees WLV. For these combustion plants the emission standard is adjusted into 650 mg/m3 NO_x, in accordance with the directive 88/609/EEC.

But the competent authorities may again deviate from the emission requirements and ask for even stricter emissions or additional requirements in their permits. There are also some possibilities to raise the requirements on emission to a less ambitious level (art. 28 Bees WLV). But at least the Inspector of Environment has to be a partner in this process. These possibilities are limited: the levels set by the directive 88/609/EEC are always the upper limit. The European adjustment 1995 is already in practice in the Netherlands. It made no adjustment of regulation in the Netherlands necessary.

Formal non-compliance to 88/609/EEC: Procedures of malfunction and interruption of fuel supply

On one specific feature too little attention was paid during the translation of 88/609/EEC into Dutch legislation: On July, 20th, 1993 Dutch government was informed that the European Commission was of the opinion that Bees WLV interpreted article 8 of 88/609 wrong. This article deals with procedures in case of malfunction, interruption of the supply of low-sulphur fuel or sudden interruption in the gas-supply. The criticism only related to the new plants (permitted on or after July, 1th, 1987). On January, 6th 1995 the Bees WLV was changed in accordance to the demands from the European Commission. On that occasion also the procedures for malfunction of combustion plants that use solid fuels or `heavy' fuel oil were changed (high on sulphur; article 7 of 88/609). Normally this concerns plants with a thermal capacity of more than 300 MW, also plants that produce electricity. Although the European Commission made no remarks, equal gaps with regard to article 7 were present and repaired. In the Dutch Ministry this was perceived as a minor misunderstanding with no real consequences other than just a formality.

2.4. Electricity sector and energy policy

The 1989 Electricity law regulated the legal structure of the electricity sector. The limited liability company “NV Samenwerkende Electriciteitsproduktiebedrijven” (in short: Sep) is a central player in the system. The four large electricity producers in the Netherlands own the Sep: EPON, UNA, EZH and EPZ. This law legalized grown structures. Between the producers and the Sep there is a collaboration agreement. The Sep and this agreement was first realized in 1949 and changed often since then. Essential is that the producers were obliged to keep there capacity and locations in line with the Electricity plan. Every two years the Sep had to draw up an Electricity plan. The Sep was responsible for coordinating supply and demand of electricity and especially for the public supply of electricity. The Ministry of Economic Affairs has a say in the Electricity plan and also in the electricity prizes. Nevertheless, the Sep managed for the production costs a national pooling prize. In the research period the Sep dealt with import and export of electricity, the collective purchase of fuels, the pooling of fuel and pooling of production costs and the operational switch on and switch off of individual plants. So Sep coordinated production. Finally the Sep operated a financial counting program that is computerized and is, including environmental costs, the basis for settlement of variety in cost prizes of different power plants.

Normally it is the policy that power plants are equipped to function on more than one fuel. In early years the producers free in the choice of fuels. This freedom was since the seventies restricted. Until the early seventies it was expected, and the Sep promoted, the increase of natural gas as fuel in power plants with oil as second fuel. Gas could be switched of during winter. Production on oil was the alternative, being switched of if the air quality standards on SO2 were exceeded. The oil crises in the early seventies, the Netherlands suffered under an oil boycott, changed this policy. International agreements within the International Energy Agency and the European Union led to prioritize oil and coal.

A national policy on the use of fuels was formulated by the end of the seventies. An agreement on the use of fuels was discussed between the electricity sector and the national government (both environmental affairs and economic affairs). Since 1980 there is a plan for the use of fuels in power plants (Brandstofinzetplan Centrales). First it aimed at a maximum proportion of coal, the emissions of SO2 should be decreased and energy saved. Nuclear power still was an option that could be expanded. In those years it was expected that more coal and more oil were going to be used. Since 1974 more units were built that could burn oil. Uncertainties on the supply of oil and prize development bended back this development. Since Tjernobyl nuclear power is out. Sep looked for another secure and cheap fuel and again coal was prioritized. The advantage of its low prize is partially undone by the necessary investments for environmental protection. The same problem holds for oil and, also because reduced gas-prizes, the use of gas in gas/oil equipped plants increased since 1985. For the research period the inputs of fuels are analyzed and found reasonable stable. Nowadays the use of coal is once again questioned. Not because of the SO2 and Nox emissions but because of the relatively high CO2 emissions.

On the economic structure of the electricity- producing sector (Arentsen et al, 1997): Merging led to a decrease of companies from 16 in 1984 to a number of 4 in the research years. The described system is a co-ordinated oligopoly, and in fact a monopoly. Nevertheless there was some overproduction during the research period. This was caused by the fact that de-central capacity increased. For environmental reasons the government supported decentralised electricity production. Industry installed combined heat and power technology. This capacity was not integrated in the Electricity plan, and so overproduction was introduced. Some industries sold electricity to the electricity distributor. This way, already during the research period the number of electricity producing companies was increased. The European Union speeded up things demanding competition and open markets. The four Dutch electricity producers talked about merging but did not until today. Since 1992 European and national debates on the liberalisation of the power production sector is going on. Nowadays large foreign companies try to buy one or more of the four Dutch electricity producers in order to enter directly the Dutch market on a large-scale basis. Small consumers still have to buy from the regional distributor, large companies can chose their own distributor. Negotiations are going on between two of the large Dutch electricity producers about foreign take-over. The sale is likely to be agreed upon. Of course this has large consequences. There is some manoeuvring going on to maintain as much as possible protection of the market and the pooling system. Still the consequences for the willingness to accept stricter environmental constraints are large. Until today the electricity producers are not willing to agree on a second covenant. They are afraid of the influence of rising environmental costs on their competitiveness. This explains the strategically change on the instrumentation on the policy side as has been discussed in paragraph 2.2.

2.5. Voluntary agreement on the reduction of SO2 and NOx emissions from power plants

With regard to existing combustion plants, the European Member States had to implement a plan to reduce the emissions in order to achieve the levels that are required by 88/609/EEC. The Member States may choose the instruments they want to use. The Netherlands did use the Bees WLV1987 and 1991 and a voluntary agreement to transform the electricity sector. This transformation is however not causally linked the European

Directive but to the Dutch acidification policy. In fact a voluntary agreement was reached with the electricity sector for an additional effort until the year 2000 on top of the Bees 1987 and 1991.

This agreement was reached under the threat of additional and stricter regulation on SO2 and Nox. The cause of all this was therefor **not** 88/609/EEC but the Dutch acidification policy.

For the studied period 1990-1996, a covenant was agreed upon between governments and the electricity sector.

The covenant

Involved parties, their motives and interests

The covenant is agreed on by the Dutch central government, represented by the Ministry on Housing, Physical planning and the Environment, the limited liability company "NV Samenwerkende Electriciteitsproduktiebedrijven" (in short: SEP), the individual electricity plants and twelve provinces. The individual electricity companies authorized the limited liability company (under private law as most large private companies) to sign the covenant. The shareholders of the Sep are the four large electricity producers: EPON, UNA, EZH and EPZ.

According to the representatives of the Dutch Ministry of Housing, the parties engaged in the negotiations as usual. This means that first of all, negotiations were engaged under the threat of regulation. Government left no doubt that whenever parties did not reach an agreement voluntary, regulation will follow. Full-fledged goal attainment for acidification was on the agenda of the representatives of the Ministry. The goals to be reached were non-negotiable. On the side of the power plants, the typical behavior of large combustion plants was observed. There was reluctance to end-of-pipe measures. Industry normally tries to gain as much flexibility as possible and tries to gain absolute freedom in reaching the emission ceilings agreed upon. Whenever expectations are that secondary measures are necessary for electricity plants, negotiations harden. This was also the case during the negotiations on the voluntary agreement in the electricity sector. But the Sep also tried to lower the goals to be reached for. It soon became clear to them that this was not attainable and the thread of stricter regulation was too serious for the electricity sector, especially for the existing plants. Still a settlement for malfunctions of abatement equipment was added to the covenant. Existing regulation made end-of pipe technology for SO2 abatement already inevitable for new plants and eventually inevitable for existing plants. So in this perspective the fight was on the Nox emissions and the prescription of end-of-pipe technology.

The covenant did not add anything to the emission requirements for SO2 for *every individual* power plant. Consequently the sector of power plants were not confronted with any additional requirements in terms of concentrations on existing plants. The 400mg/m3 combustion gas limit on SO2 did not require any new technology on top of BEES. This level can be achieved by 85 % abatement, 1.27 % S-coal. Nevertheless the overall emission ceiling for the sector as a whole was established much lower in the covenant and in line with the policy documents mentioned. Some plant did not install the necessary end-of pipe technology yet. The trade-off was made for old coal-fired electricity plants that until closing down (before 1995) the plants were allowed to produce without additional demands on top of Bees- WLV 1987/1991. For plants larger than 300 MW that were still in use after 1994, 85% desulfurication of combustion gasses is required in Bees. These plants were not obliged to install end-of pipe technology, nevertheless as far as SO2 is at stake, in a material sense there are no alternatives for coal-fired plants. The emissions limit and 85% abatement is achieved cost-effective with a wet washer.

The real bottleneck in the negotiations was in the emission ceiling for NOx. It was apparent that NSCR/SCR technology was necessary. The power plants required total freedom in the choice of either primary or secondary measures. Basically they have gotten that. For the central government and the SEP there were also some considerations in order to secure electricity supply. Diversity on fuels was therefor appreciated. For that coal-fired plants are desirable next to gas fired plants. Normally the gas-fired plants can also be fired on oil. If they use oil SO2 emissions are up. But oil is rarely fired in these electricity plants, mostly this concerns days on which it is extreme cold, in order to relieve gas supply. On these dominantly gas fired small plants, no SO2 abatement technology is required. Of course recently coal-fired plants are brought into disrepute at the level of the central government because, in comparison with gas-fired plants, they produce substantially more CO2.

The outcomes of the game

The outcomes were satisfying for both parties. A substantial reduction of SO2 and NOx emissions was combined with freedom for the electricity sector to implement in the most cost-effective way. The goals were on the aggregate level of the sector and not on the level of individual electricity plants.

The consequence of the covenant that was signed on June 12^{th} 1990 in detail:

Obligations for the year 2000 for the electricity sector

The Limited Liability Company SEP and the individual electricity plants committed themselves to substantial efforts to decrease the emissions of SO2 and NOx between 1990 and 2000. This decrease is defined on the aggregate level of the electricity plants. The emission ceiling of the year 2000 is 18000 tons SO2 and 30000 tons NOx . For the year 1994 the ceiling for SO2 emissions is 30000 tons. So the tempo on reduction of SO2 is faster than in the policy documents mentioned.

In case of malfunction of desulfurication equipment in coal fired electricity plants, and the plant is within legal limits, the emission ceiling is raised by 4000 tons SO2. This corrected ceiling can be exceeded by 3000 tons once every three years.

Within a period of six month a plan had to be produced by the SEP that explained how the sector is going to be restructured in order to reach for the targets. This plan was object of interaction with a commission. The provinces appointed two members the Minister of Housing, Physical Planning and Environmental Affairs appointed two members to this commission, and two were appointed by the SEP. In every even year the SEP had to present a report to the commission on the implementation of the covenant. Basic success-factor of this covenant is believed to be that it is not about endeavors but about results. If results are not achieved regulation will follow and prescription of technology will follow.

Plan for the implementation of the covenant

It is important to notice that the SEP was in the period 1988-1995 extreme powerful within the electricity sector. They coordinated even the application of individual power plants and there was a system settlement/balancing of cost prices. Only recently liberalization and the growing level of competition changed this situation. In 1999 the SEP was dismantled. In the period 1988-1995 they were however ruling the electricity sector. Basically there were four corporate electricity producers: EPO, UNA, EZH and EPZ. The allocation of emission reduction over these four producers and their individual plants was no problem. The SEP operated a system of cost-price settlement/balancing. Next figure gives the expectations of the SEP on emissions of SO_2. Choices already made seemed to make the 1994 SO2 ceiling attainable, to reach out for the 2000 SO2 ceiling some additional choices had to be made.

Figure 3: Kilotons emissions SO_2 expected by the SEP in 1991 (source: Plan van Aanpak 1991)

1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
54	45	43	30	33	32	31	33	33	26

A first type of instrument was the closedown of five coal-fueled plants that had no abatement equipment for SO_2. These plants were “Gelderland 12”, “Amer 41”, “Amer 51”, “Maascentrale 4” en “Maascentrale 5”. Finally will the “Maascentrale 6” was planned to be closed down in 1999/2000.

Two new coal-fueled plants will be put into operation: “Amer 91 and “”Hemweg 8”.

In the year 2000, after the last “old plant” “Maascentrale 6” should be closed, all coal-fueled plants will have abatement equipment for SO_2. This concerns the existing units “Gelderland13”, “Maasvlakte1”, “Maasvlakte2”, “Borssele12”, “Amer81” and the new units “Amer91” and “Hemweg8”.

Additional abatement is expected from low-sulfur coal, abatement of more than 90% and less malfunctions in the abatement equipment.

Progress reports

The implementation of the “Plan for the implementation of the government” was reported every even year. This means that the first report issued in 1992 covers the years 1990 and 1991. The fourth report covered the years 1996 and 1997. The most important events:

-The plant “Gelderland 12” was closed down late 1990

-The plant “Maascentrale 4” was closed down late 1991

-The plant “Amer 41” was closed down (replaced by “Amer 91”)

- The plant “Amer 51” was closed down (replaced by Amer 91”)

- The plant “Maascentrale 5” was closed down

- The plant “Maascentrale 6” was planned to be closed down late 1999 or early 2000, actually it was closed down early 1997.

Put in operation new coal-fueled plants with full abatement equipment:

- Amercentrale 9 (A-91) 1/7/93 (replaces Amer 41 and Amer 51)

- Hemwegcentrale (HW-8) 1/7/94

The progress reports gave data on emissions, % S in coal used, and additional emissions because of malfunctions. Where relevant the data will be reported that will be used in the next paragraph.

2.6. Monitoring and enforcement

The Sep came up with the required plan for the reduction of emmissions within six months. This plan was object of interaction with the commission. The commission approved of the plan.

As mentioned, the Sep had to produce a report on the progress made every two years. Meetings between the Sep and the commission were always held in a positive atmosphere and satisfying for Sep, central government and provinces. The reason for all this is of course very simple: implementation was done according plan and the goals were achieved.

Of course sometimes a technique of technologies did not perform as was expected. For that reason some of the about seventy measures being planned were altered. Most frequently this was the case for Nox emissions, technology for SO2 was already more mature.

Nevertheless there were three points of more serious discussions (Brand, 1999): One of them is the easy realization of the reduction of SO2 emissions. This was something the provinces didn't like and reinforced them in the idea that maybe with regulation even more could have been achieved. Part of the covenant was of course that provinces would not make regulation in permits more strict as long as the electricity producers complied to the covenant. The power producers and the central government were not prepared to re-open negotiations. A second item that was discussed was the over-performance of the installed abatement equipment. In the covenant involved parties agreed on 85% abatement. Actual abatement was 90-95 % (compare figure 7). The Sep wanted to run at 85% because that is a bit cheaper. That is one way the Sep wanted to use the room that was created due to over-compliance. The other way, and that was the third point of discussion, the Sep wanted to use cheaper coal with a higher percentage of sulfur, also filling in over-compliance-room. Although Sep formally proclaimed that this was not good, in practice, as our empirical analysis suggests, it was practiced.

Besides the monitoring of the covenant, the air-emissions are also monitored by the permitting authority. For larger power plants, such as electricity plants, this is a task for the province.

Provinces held a low profile as agreed upon. The electricity plants are visited periodically. The checks are not only related to air-emissions but to all aspect that are (environmentally) regulated. It was recognized that it was unlikely that the electricity plants would exceed the regulated emission standards as set in Bees. Simply because the covenant is more ambitious and the Plan of action of The SEP kept the regulated emission limits into account. For malfunctions in the abatement equipment there is a settlement in Bees.

Normal procedures are that when there are malfunctions in abatement equipment, the company has to report this to the province. This certainly does not mean that we are speaking about reinforcement at once. Under certain conditions the plant can produce for 72 hours when the emission standard is exceeded. If the malfunction is not repaired within this time-limit other measures have to be taken, this could be fuel s switch or total switch of. Because of the coordinating function of SEP this was no problem.

3. Environmental effectiveness

3.1 Environmental effectiveness: the aggregate level of combustion plants

The basis for calculations in the Directive 88/609/EEC, the emissions of large combustion plants in 1980 was estimated at 299 kilotons SO2, estimated by experts. Dutch ministry claimed it to have been 325 kilotons in 1980.

Figure 4: SO2 emissions (kilotons/year) of large combustion plants as reported to the European Union

	1990	1991	1993	1994	1996
Refineries	49.5	50.8	44.4	41.6	31.8
Power plants*	43.7	37.5	22.1	14.6	18.7
Chemical industry**	9.1	8.2	8.7	9.5	5.8
Other industry***	1.8	1.7	1.4	1.3	0.6

*): The Power plants as category is equivalent the EC category "Public power plants"

**): The Chemical industry as category is equivalent the EC category "Industrial plants"

***): The Other industry as category equals the EG category "Commercial plants" + "Other"

Indicators for environmental effectiveness, all large combustion plants:

Targeted Directive level (Y*) for 1993: 180 kilotons SO2

Targeted Directive level (Y*) for 2003: 120 kiloton SO2 (-60%)

Indicator 1: $\wedge Y = Y^f / Y^*$ x 100 = 56.9/163.64 x 100 = 34.8

Y^*_{1996}=163.4 kilotons SO_2 (1993: 180 kiloton, 2003 120 kiloton)

Y^f= 56.9 ktons (1996)

Indicator 2: $\wedge Y = (Y^0 - Y^f)/Y^0$ = (104.1 – 56.9)/104.1 = 0.453

3.2 Environmental effectiveness at the aggregate level of power plants

Next figure gives the emissions of SO_2 from 1980-1989:

Figure 5: Kilotons SO2 emissions the (according to the SEP, Plan van aanpak 1991)

1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
196	210	148	94	72	64	66	64	65	41

The explanation for the small emissions in 1989 compared to 1990 is the low use of coal-capacity, the availability of low-sulfur coal and almost no malfunctions in the abatement equipment.

Figure 6 gives the developments in the period 1990-1996:

Figure 6: kilotons SO2 emissions (according to the SEP in four progress reports)

	1990	1991	1993	1994	1996
Power plants*	43.7	37.5	22.1	14.6	18.7

In 1980 emissions of power plants were 196 tons SO2. In 1985 this was reduced to 64 tons SO2. Targeted Directive level 1993 180 kiloton SO2 (-40%)

2003 120 kiloton SO2 (-60%)

Indicators for environmental effectiveness all large combustion plants:

Y^{*}_{1996} = 106.9 kilotons (extrapolated on 1980 emissions of power plants)

Indicator 1: $\wedge Y = Y^f/Y^* \times 100 = 18.7/106.9 \times 100 = 17.5$

Y^*_{1996}= 106.9 kilotons SO_2 (extrapolated, 1993: 117.6 kiloton, 2003 78.4 kiloton)

Indicator 2: $\wedge Y = (Y^0 - Y^f)/Y^0 = (43.7 – 18.7)/43.7 = 0.57$

3.3. Explanation of reduction established: dissentanglement

Disentanglement of decrease of 25 kilotons SO_2 (1990 43.7 kilotons 1996 18.7 kilotons)

Factor 1: Closure of coal-fired plants without abatement technology (total capacity closed 985 MWe:

G12	4.673
VN 22/23	0.835
A 41	6.437

A 51	6.867
MC4	3.774
MC5	5.102
Total:	27.688 kilotons (-)

Factor 2: New coal-fired plants with abatement equipment (total new capacity 1200 Mwe):

HW8	2.712
A91	2.648
Total:	5.36 kilotons (+)

Factor 3: Fuel-substitution

The next figure illustrates the fuel substitution. In the Dutch emission inventory system similar fuel types (fossil) are registered uniformly by expressing the different heat contents in equivalent units (J).

Figure 7: Energy consumption in energy units (PJ/year)

	1990	1991	1994	1996
Power plants	447 (100%)	444(100%)	418 (100%)	382(100%)
Solid	232 (52%)	202(45%)	197 (47%)	236 (62%)
Liquid	2 (0%)	1 (0%)	2 (0 %)	1.3 (0%)
Gaseous	214 (48%)	241 (54%)	220 (52 %)	145 (37.8)

Compared to 1990 the changes in fuel-inputs are marginal if we take relevance for SO2 emissions into the analysis. The use of coal is increased with about 4 PJ, the use of blast combustion gas is down 1.2 PJ, the use of oil is down 0.7 PJ.

Without abatement equipment the extra coal means additional 2.43 kiloton SO2 emissions (0.8% S in coal). Note: the extra used coal is not by definition fired in power plants without abatement equipment. The only plant left in 1996 without abatement equipment is MC6 “Maascentrale 6”. This plant only produced 4.2 % of the electricity produced in coal-fired plants. The other plants perform on average 92 % abatement. This means that the actual increase because of the additional coal-input will be about 0.28 kiloton SO2 (normalized: 0.042 x 2.34 + 0.958 x 0.08 x 2.34).

Without abatement equipment the decreased use of blast combustion gas means 0.13 kiloton SO2 (-).

Without abatement equipment the decreased use of oil means 0.34 kiloton SO2 (-). Figures given by the gas/oil fired electricity plants that are reported individually in this case-report add up to an increase of 0.1 kiloton which cannot be explained otherwise than by the S% of the oil used or a small deviation in the input figures given. Because the importance of this is minor, in the analysis the empirical numbers given by the plants could be used.

Factor 4: changes in **%** S in coal

The actual % S in coal used was in 1990 0.7%. In 1996 it was 0.85%. This means of course an additional emission of SO2 that can be estimated on 2.2 kiloton. This increase of %S was market driven, an additional factor was that the transitional period for older power plants ended 1994. So after an initial decrease of the average % S driven by regulation on older, existing power plants, the sector could raise the %. For more information on this see paragraph 5 on productive efficiency (figure 40).

Calculations above are based on: Emission without abatement 0.8 % S 608 g/GJ, Emission without abatement 1.27 %S 967 g/GJ (Bakema en Kroon, 1988 p. 134) and found average abatement level 92%. Estimation: (967- 608)/4.7 x 1.5 x 0.08= 9.16 g/GJ x 236 PJ produced on coal = 2.2 kiloton).

Factor 5: malfunctions

In 1990 0.505 kiloton additional emissions because of malfunctions

In 1996 0.545 kiloton additional emissions because of malfunctions

So this means a marginal extra emission of 0.045 kiloton (+)

Factor 6: abatement

Figure 8 gives the % abatement (desulferication)

Figure 8: % desulferication (according to the SEP in four progress reports)

	1990	1991	1994	1995	1996	1997
G-13	91.2	91.4	92.1	92.5	92.7	93.6
MV1	88	90.5	93.0	92.4	91.8	91.0
MV2	88	89.8	93.0	92.4	91.8	91.1
BS12	95.0	95.2	94.6	93.8	92.8	92.2
A-81	90.6	91.7	92.8	90.5	90.9	92.0
A91			92.9	91.5	92.1	91.3
HW 8			92.0	91.5	90.0	91.2

Quantitative:

On the basis of the emissions in 1996 on individual plant basis, and given developments in the area of desulferication it can be assessed that the improvement of the abatement equipment reduced the emission by 1.4 kiloton (-).

Qualitative:

Five electricity plants have a full abatement line in which SO2 is converted in gypsum. In a washing vat SO2 is contacted with lime. Calciumsulfiet is produced. This is oxidized into calciumsulfiet. Insulation of washing towers/washing vat and replacement of rubber upholstery was done in 1992 and 1993 at Maasvlakte 1 en 2, Gelderland 13, Amer 81 en Borssele 12.

Total

Decrease of 25 kiloton

Factor 1: 27.7 kiloton (-)

Factor 2: 5.4 kiloton (+)

Factor 3: 0.28 kiloton (+)

0.34 kiloton (-)

Factor 4: 2.2 kiloton (+)

Factor 5: 0.045 kiloton (+)

Factor 6: 1.4 kiloton (-)

Total 21.5 (-).

The difference 3.5 kilotons is unexplained

Zero based dissentanglement

Of course with the same factors the disentanglement can be done with an effort to explain the total emission in 1990 and 1996:

1990

The estimate for the emissions in 1990 is 124 kiloton SO2 without abatement, based on 0.7% S in coal (calculation on fuel input basis without abatement, 0.8 % S in coal leading to an emission of 608 gr/GJ**).** This can be **cross-checked** with figure 8 and emissions individual power plants that are given in paragraph 3.4. Cross check on this basis leads to an estimated emission of 131 kilotons). We use the 124 kilotons.

Depending on the source, real emissions were between 43.7 and 44.4 kiloton SO2. We calculate with 44.4 kilotons

The actual average abatement level is 68.3 % (High percentage is achieved by low utilization of coal-fired plants without abatement equipment).

Malfunctions in abatement equipment causing about 0.5 kiloton additional SO_2.

1996

In the status quo position emissions without abatement would of course have been again 124 kilotons.

Theoretically, emissions would have gone up to 125.7 kilotons, due to an increase of the use of coal (factor 1.014). Cross check with figure 8 and emissions of individual power plants, leads to an emission of 153 kilotons. The explanation of the large misfit is simple, this is not a valid cross check because of the increased average %S in coal compared to 1990.

The average % of S in coal is up, this would lead theoretically to an additional emission of 26.9 kilotons, leading to a total of 0.214 x 125.7 = 152.6 kilotons. Now the crosscheck is valid: If we **crosscheck** with figure 8 and emissions individual power plants. Crosscheck on this basis leads to an emission of 153 kilotons, a marginal misfit.

Level of abatement rose from 64.2 % to 89 % (including plant “MC6" which has no abatement line). This leads to an emission of 0.11 x 152.6 kilotons = 16.8 kilotons.

Adding the malfunctions is about 0.5 kiloton, leading to an emission of 17.3 kiloton

Some sources mention a total emission of 18.7, leaving 1.4 kiloton unexplained.

On 88/609/EEC as a causal factor

The experts at the ministry for Housing, Physical Planning and Environmental Affairs reject the suggestion that the covenant was caused by 88/609/EEC. It was a logical step in the implementation of the acidification policy. The alternative was to harden the national legislation far beyond the requested levels by 88/609/EEC. That the covenant in fact can be used as the instrument with which the Dutch government are complying with their obligations for emission reduction targets and plans is seen a just comfortable coincidence.

3.4 Environmental effectiveness at the plant level.

The covenant covered 83 production units. A lot of them are only fired by natural gas and therefor not emitting SO_2. Basically there are three kinds of power plants that emit SO_2 of which only two kinds are important for key-analysis. These are power plants that are fired with coal or blast furnace gas. The third kind of electricity plant that emits SO2 are the power plants that normally are fired on natural gas but sometimes are fired on oil. Mostly this is done on very cold days to relief the gas supply. The emissions involved are minor on only relevant to complete the analysis in a formal way. The simple reason for this is that these emissions are very small and very little attention is given to these sources of SO2 emissions, these power plants are preferably fired with natural gas.

There are four corporations in the Netherlands: EPON, UNA, EZH and EPZ. The core of analysis will be on the coal-fired plants and the blast furnace plants. Some secondary attention will be paid to the influence on SO2 emissions of gas-fired plants that on extreme cold days sometimes are being oil fired. For the overview emissions are relevant of these plants, nevertheless because in these plants are not transformed for their SO2 emissions limited analysis is done on them.

3.4.1 Electricity producer EPON

* Total SO2 emissions of EPON-plants:

Figure 9: Total emissions SO2 from EPON (tons)

	1989	1990	1993	1994	1996
Total EPON	7477	6817	2852	2091	2249
Coal fired plants	7100	6657	2725	2037	2188
Gas/oil fired plants	377	162	127	54	61

* SO2 emissions of coal fired EPON-plants:

G 12 “Gelderland 12” , brought into use 1963, can also be fired with oil, capacity 115 Mwe

Figure 10: Total emissions SO2 from EPON plant G12 “Gelderland 12”(tons)

	1989	1990	1993	1994	1996
G-12 Fuel: coal	5700	4673	Closed	Closed	Closed
% S in coal		0.67	-	-	-
Electricity produced	-	-	-	-	-

G 13 “Gelderland 13” , brought into use 1981, can also be fired with oil, capacity 602 Mwe

Figure 11: Total emissions SO2 from EPON plant G13 "Gelderland 13"(tons)

	1989	1990	1993	1994	1996
G-13 Coal	1400	1984	2752	2037	2188
% S in coal	-	0.66%	0.52%	0.56%	0.87%
Electricity produced	-	-	3536GWh	2970GWh	3192GWh

* Emissions of gas/oil fired EPON-plants:

Figure 12: Total emissions SO2 from EPON plants that are gas/oil fired (tons)

	1989	1990	1993	1994	1996
HC50 Gas/oil	25		-	-	12
FL-1 Gas/oil	350	42	20	6	-
Fl-2 Gas/oil	-	2	14	-	
Fl30 Gas/oil		114	93	48	38
BCGI Oil/gas	2	2	-	-	
HC60 Gas/olie	-	-	-	-	11

3.4.2 Electricity producer UNA

* Total SO2 emissions of UNA-plants:

Figure 13: Total emissions SO2 from UNA (tons)

	1989	1990	1993	1994	1996
Total UNA	1647	1849	1125	4514	3309
Coal fired plants	-	-	74	1291	2712
Blast furnace gas fired	1543	1739	839	3129	575
Gas/oil fired plants	104	110	212	94	22

* SO2 emissions of coal fired UNA-plants:

HW 8 “Hemweg” , brought into use 1994, can also be fired with oil, capacity 600 Mwe

Figure 14: Total emissions SO2 from UNA plantHW8 “ Hemweg 8”(tons)

	1989	1990	1993	1994	1996
HW 8 Coal/gas	New	New	74	1291	2712
% S in coal				0.73 %	<1 %S
Electricity produced			727 GWh	3376GWh	3827GWh

* SO2 emissions of blast Funace Gas fired UNA-plants:

VN22 and 23 “Velsen 22 and23” , brought into use about 1966, can also be fired with oil, capacity about 127 Mwe

Figure 15: Total emissions SO2 from UNA plants VN22 and 23 “Velsen 22 and23” (tons)

	1989	1990	1993	1994	1996
VN 22/23 Blast furnace gas/ oil	-	835	Closed	closed	Closed

VN24 “Velsen 24” , brought into use 1974, can also be fired with natural gas and oil, capacity about 459 Mwe

Figure 16: Total emissions SO2 from UNA plants VN24 "Velsen 24" (tons)

	1989	1990	1993	1994	1996
VN 24 Blast furnace gas/gas/oil	522	660	262	611	93
% S					
Electricity produced	-	--	1893GWh	1668GWh	1467GWh

VN25 "Velsen 25", brought into use 1986, can also be fired with natural gas and oil, capacity about 361 Mwe

Figure 17: Total emissions SO2 from UNA plant VN25 "Velsen 25" (tons)

	1989	1990	1993	1994	1996
VN 25 Blast furnace gas/gas/oil	1021	244	577	2518	482
% S					
Electricity produced			2469GWh	2826GWh	2844GWh

* Emissions of gas/oil fired UNA-plants:

Figure 18: Total emissions SO2 from UNA plants that are gas/oil fired (tons)

	1989	1990	1993	1994	1996
HW5 gas/oil	9	5	Closed	closed	Closed
HW6 gas/oil	14	8	11	closed	Closed
HW 7 gas/oil	56	-	54	-	17
DM31 gas/oil	-	28	31	12	Closed
DM32 gas/oil	-	26	88	73	Closed
LW5 gas/oil	25	43	28	9	5

3.4.3 Electricity producer EZH

* Total SO2 emissions of EZH-plants:

Figure 19: Total emissions SO2 from EZH (tons)

	1989	1990	1993	1994	1996
Total EZH	3700	3742	2004	2042	3114
Coal fired plants	3540	3710	1988	1806	3043
Gas/oil fired plants	160	32	16	236	71

* SO2 emissions of coal fired EZH-plants:

MV1 “Rotterdam MV1”, brought into use 1988, can also be fired with oil, capacity 518 Mwe

Figure 20: Total emissions SO2 from EZH plant MV1 “Rotterdam MV1”, (tons)

	1989	1990	1993	1994	1996
MV-1 coal/gas	1700	1640	1107	881	1532
%S in coal		0.55%	0.55%	0.50%	0.76%
Electricity Produced			3918GWh	3636GWh	3410GWh

MV2 “Rotterdam MV2”, brought into use 1987, can also be fired with oil, capacity 518 Mwe

Figure 21: Total emissions SO2 from EZH plant MV2 “Rotterdam MV2”, (tons)

	1989	1990	1993	1994	1996
MV-2 coal/gas	1840	2070	881	925	1511
%S in coal		0.55 % S	0.55%S	0.50 % S	0.76%S
Electricity Produced			3415GWh	3630GWh	3406GWh

* SO2 emissions of gas/oil fired EZH-plants:

Figure 22: Total emissions SO2 from EZH plants that are gas/oil fired (tons)

	1989	1990	1993	1994	1996
FW 4 gas/oil	69	30	-	117	14
FW 5 gas/oil	79	-	-	117	46
CM 3	7	-	-		
CM 4	5	-	-		
DO-6 gas/oil	-	2	16	2	11

3.4.4 Electricity producer EPZ

* Total SO2 emissions of EPZ-plants:

Figure 23: Total emissions SO2 from EPZ (tons)

	1989	1990	1993	1994	1996
Total EPZ	28430	32407	16072	9199	10021
Coal fired plants	28303	32305	16072	9199	9554
Gas/oil fired plants	127	102	-	-	367

* SO2 emissions of coal fired EPZ-plants:

BS 12 "Borssele 12", brought into use 1987, can also be fired with gas, capacity 403 Mwe

Figure 24: Total emissions SO2 from plant BS 12 "Borssele 12" (tons)

	1989	1990	1993	1994	1996
BS 12 coal/gas	1015	781	410	850	1263
%S in coal		0.75 %	0.48 %	0.66%	0.78%S
Electricity Produced			1634GWh	2716GWh	2584GWh

A-41 “Amer 41 , brought into use 1965, can also be fired with gas, capacity 223 Mwe

Figure 25: Total emissions SO2 from plant A-41 “Amer 41” (tons)

	1989	1990	1993	1994	1996
A-41	7012	6437	4519	closed	Closed
%S in coal		0.81 %	0.79%	closed	Closed
Electricity Produced			1008GWh		

A-51 “Amer 51, brought into use 1966, can also be fired with gas, capacity 223 Mwe

Figure 26: Total emissions SO2 from plant A-51 “Amer 51” (tons)

	1989	1990	1993	1994	1996
A-51	5942	6867	4461	closed	Closed
% S in coal		0.81 %	0.71%		
Electricity produced			988GWh		

A-81 “Amer 81”, brought into use 1980, can also be fired with oil, capacity 645 Mwe

Figure 27: Total emissions SO2 from plant A-81 “Amer 81” (tons)

	1989	1990	1993	1994	1996
A-81 Coal/oil	3623	2525	1728	1559	1771
%S in coal		0.73%	0.53%	0.65%	0.94%
Electricity produced			4157GWh	3387GWh	2449GWh

MC-4 “Bruggenum 4 , brought into use 1961, can also be fired with oil, capacity 120 Mwe

Figure 28: Total emissions SO2 from plant MC-4 “Bruggenum 4 ” (tons)

	1989	1990	1993	1994	1996
MC-4	2932	3774	Closed	closed	Closed
% S in coal		0.77%			

MC-5 “Bruggenum 5, brought into use 1966, can also be fired with gas, capacity 177 Mwe

Figure 29: Total emissions SO2 from plant MC-5 “Bruggenum 5” (tons)

	1989	1990	1993	1994	1996
MC-5	4187	5102	Closed	closed	Closed
% S in coal		0.77%			

MC-6 “Bruggenum 6 , brought into use 1986, can also be fired with gas, capacity 233 Mwe

Figure 30: Total emissions SO2 from plant MC-6 “Bruggenum 6” (tons)

	1989	1990	1993	1994	1996
MC-6 coal/gas	3592	6819	4439	5514	3972
%S in coal		0.77%	0.70%	0.58%	0.62%
Electricity produced			1079GWh	1336GWh	1033GWh

A-91”Amer 91”, brought into use 1993 can also be fired with gas capacity 600 Mwe

Figure 31: Total emissions SO2 from plant A-91”Amer 91” (tons)

	1989	1990	1993	1994	1996
A-91 coal/gas			515	1276	2648
%S in coal			0.53%	0.63%	0.95%
Electricity produced			2036GWh	3812GWh	4165GWh

* SO2 emissions of gas/oil fired EZH-plants:

Figure 32: Total emissions SO2 from EZH plants that are gas/oil fired (tons)

	1989	1990	1993	1994	1996
CCA gas/oil	27	6	-		13
CCB gas/oil	100	96	-		354
A 61 gas/oil	-	-	-	-	-
A 71 Gas/oil	-	-	-	-	-

3.5. Some conclusions on environmental effectiveness

Time series on SO2 emissions of power plants indicate two moments in which tendencies shifted. After a rapid decrease in the years 1980 until 1984, emissions were relatively stable between 1984 and 1989. In 1989 an exceptional small use of coal capacity runs in front of the start of a new period of decrease between 1989 and 1996. In the period 1990-1996 the prime explanation is not a small use of coal as fuel but the use of low-sulfur coal, improvements on abatement equipment, the close down of old coal fired plants without abatement equipment and the construction of two new coal fired plants with abatement equipment. The use of different types of fuel and also the available coal fired capacity has not changed substantially. On the aggregate level of the power plants the qualitative analysis made clear that the European Directive 88/609 is *not* linked to the established reductions in emissions.

The conclusion that the total reduction in SO2 emissions is causally linked to the covenant is tempting. There are however some considerations that should be taken into account before making such a statement. First the covenant was agreed upon in a period of growing political and public awareness of environmental damage in the late eighties. The acidification policy and stricter regulation and the threat of even stricter regulation are important explanatory factors. The threat to the electricity producers that they had to face stricter emission limits in the years to come is a key driver that made the covenant possible. This created the setting in which a voluntary agreement was within reach under the condition that no additional regulation would be issued during the period of the covenant.

If the covenant were not agreed upon, the regulation would have become stricter. The statement that the same environmental goals would have been reached by this alternative regulation approach can only be presented with some caution. Nevertheless provinces think that it would not have been unthinkable that even stricter emission limits could have been possible.

Still the decrease of SO2 emissions is due to measures that the electricity-producing sector imposed on itself. Still, existing regulation was certainly not put out of order. When we look therefor at the closing down of the old coal fired plants we have to keep in mind that these are really old plants at the end of their life span. When we look at the two new large coal fired plants we have to keep in mind that existing regulation required abatement technology abating at least 85% and also limited the emission of SO2 /m3. This results in a constraint on the % sulfur in coal to be fueled in these new plants.

The general conclusion is that there are no reasons to deny that the covenant was the prime driver for changes made, still existing regulation and the avoidance of the alternative instrument are important factors to keep in mind when analyzing the changes made. Finally SO2 emissions could have been even less when the new coal-fired plants would not have been built. The energy-policy on fuel differentiation and the strategy of Sep to secure cheap fuels explain the building of these new plants. The additional SO2 emissions created no problems, for the Nox emissions it made no substantial difference.

4. Allocative efficieny

4.1. Abatement patterns

In the IMPOL project the individual abatement pattern is given by the fraction of the initial emission (^Y) that has been abated. The initial emission Y^0 in this case study is expresses as tons in 1990, Y^f is the emission in tons in 1996. So the indicator and the outcomes on the individual plants are:

Indicator: $\hat{}Y = (Y^0 - Y^f)/Y^0$ on plant level:

G 12 “Gelderland 12” (5700 – 0)/5700 = 1

G13 “Gelderland 13” (1984 – 2188)/1984 = -0.10

HW 8 “Hemweg” (0 – 2712)/0 = -

VN 23 “Velsen 23”= (835-0)/835 = 1

VN 24 “”Velsen 24” = (660-93)/660 = 0.86

VN 25 “Velsen 25” = (244-482)/244 = -0.96

MV-1 “Rotterdam MV-1” = (1640 –1532)/1640 = 0.06

MV2 “Rotterdam MV-2” = (2070 – 1511)/2070 = 0.27

BS 12 “Borssele 12” = (783 – 1263)/783 = -0.61

A41 “Amer 41” = (6437 – 0)/6437 = 1

A 51 “Amer 51” = (6867 - 0)/6867 = 1

A-81 “Amer 81” = (2525 – 1771)/2525 = 0.30

MC-4 “Bruggenum 4” = (3774 – 0)/3774 = 1

MC-5 “Bruggenum 5” = (5102 – 0)/5102 = 1

MC-6 “Bruggenum 6” = (6819 – 3972)/6819 = 0.41

A 91 “Amer 91” = (0 – 2648)/0 = -

4.2. Cost allocation by the Sep

The large gain for the Sep and the electricity producers was the flexibility that was in the covenant. No additional regulation on the level of the individual plants was issued and the goals were formulated on the aggregate level. This left of course space to study on the most cost-effective solutions to implement the covenant. For SO2 this was reasonable well known during the negotiations on the covenant, for Nox there was more uncertainty on technology and costs. Starting point for the Sep was cost-effectiveness when they developed the plan of action, as they were obliged to by the covenant. They used their normal operating and counting program. All power plants are in and the program is used for balancing the cost-prizes of electricity producers. This is necessary of course in a system in the Sep decided when every individual plant has to be switched on or switched of. On the basis of a scenario until the year 2000, the necessary abatement was known. The four electricity-producing companies indicated what they could do to decrease emissions. After a first shake out, detailed costs estimates were made. The openness of the process was enormous according to the respondents from the Sep. A crucial factor in this was of course the existence of the cost pooling mechanism[1].

Still we have to keep in mind that the Sep could not prepare the measures in total freedom. The fact that the covenant included no additional stricter regulation, this does not mean that existing regulation was not valid. The constraints from existing regulation are discussed in the paragraph on productive efficiency.

The old coal fired plants that were closed really were on the end of their life span, this makes cost calculations difficult. The use of low-sulfur coals increased the fuel costs. In practice the electricity sector did not lower the average sulfur % in coal substantially and even tried to raise the sulfur % at some moments. There is however regulation that give an upper level of S in coal. The electricity producers did not try to raise these legal limits. The updating of abatement technology and abatement technology at the new plants were of course costly measures. More about the costs is explained in the next paragraph.

[1] The Covenant concerning the reduction of SO2 and Nox emissions, Ellis Brand, Enschede, June 1999

4.3 Cost characteristics of individual sources

The cost characteristics of individual sources are expressed by *indirect* indicators and by *direct* indicators (Eames, 1999).

Indirect indicators

Figure 33 gives the required indirect indicators and the Y^0 level of abatement by end-of pipe technology.

Figure 33: Indirect indicators on relevant power plants

Power plant	Year of Installment	Capacity Mwe	Y^0 (tons)	Y^0 level of abatement
G 12 “Gelderland 12”	1963	115	5700	~0
G13 “Gelderland 13”	1981	602	1984	91.2 %
HW 8 “Hemweg”	1994	600	-	-
VN 22/23 “Velsen 23”	1966	127	835	~0 bcg
VN 24 “”Velsen 24”	1974	459	660	~0 bcg
VN 25 “Velsen 25”	1986	361	244	~0 bcg
MV-1 “Rotterdam MV-1”	1988	518	1640	88 %
MV2 “Rotterdam MV-2”	1987	518	2070	88 %
BS 12 “Borssele 12”	1987	403	783	95.0 %
A41 “Amer 41”	1965	223	6437	~0
A 51 “Amer 51”	1966	223	6867	~0
A-81 “Amer 81”	1980	645	2525	90.6 %
MC-4 “Bruggenum 4”	1961	120	3774	~0
MC-5 “Bruggenum 5”	1966	177	5102	~0
MC-6 “Bruggenum 6”	1986	223	6819	~0
A 91 “Amer 91”	1993	600	-	-

bcg = blast combustion gas

In the figure 33 the Y^0 level of abatement is in between direct and indirect. The reason is that technology applied for SO2 is quite homogeneous in the Netherlands.

The direct indicators

An important part of the deal in the covenant is that the regulation as it is introduced in 1987 by the Bees (Staatsblad, 1987) is the position of existing plants. By the Bees 1987 it was determined that new power plant had to meet the emission limit of 400 mg/m3 and full combustion gas abatement equipment. Existing plants that were closed down before 1995 only were forced to use low-sulfur fuels (maximum 0.8% S). In the covenant in 1991the deal was made to reduce SO2 emissions substantially and on the other hand not to strengthen regulation on existing plants. For MC6 “Bruggenum 6” this meant a special status.

Basically there are three strategies applied in the Netherlands to reduce emissions of SO_2:

1. Closure of plants
2. Substitution of high sulfur coal for low sulfur coal
3. Abatement equipment

1. On the closure of plants

The closure of power plants can hardly be evaluated in economic terms. An important part of the deal in the covenant is that the regulation as it is introduced in 1987 by the Bees (Staatsblad, 1987) is the position of existing plants. By the Bees 1987 it was determined that new power plant had to meet the emission limit of 400 mg/m3 and full combustion gas abatement equipment. Existing plants that were closed down before 1995 only were forced to use low-sulfur fuels (maximum 0.8% S). In the covenant in 1991the deal was made to reduce SO2 emissions substantially and on the other hand not to strengthen regulation on existing plants. For MC6 “Bruggenum 6” that was planned to be closed in 1999/2000 this means a special status, finally it was closed already in 1997. The closed power plants were built between 1961 and 1966.

2. On lower sulfur coals

The marginal costs of these kinds of abatement measures raises from high-sulfur coal to low-sulfur coal. The price difference between 3.5%S and 0.5 % S was 9%.

In 1989 prices:

Prices of coal prices 1989 (source Wiersma, 1989, p: 84):

3.5% S: 206.05 Dutch guilders/ton

2.9% S: 207.63 Dutch guilders/ton

2.3% S: 210.26 Dutch guilders/ton

1.7% S: 213.94 Dutch guilders/ton

1.1% S: 218.68 Dutch guilders/ton

0.5% S: 224.61 Dutch guilders/ton

Energy input for Dutch coals was on average 6500 kcal/kg that equals 27083.33 kJ/kg.

3. On abatement equipment

There are dry and wet systems. The difference is in the substance that is used for absorption. Dry systems use a solid substance at high temperature. Advantage is that there is no need for re-heating the combustion gasses. That saves energy. But there are wastes to take care of. Basically there were three kind of processes considered in the Netherlands:

1. The "throw away process" technically her operational as the "lime-sludge" process. After use the absorption material lime cannot be re-used and has to be dumped which of course costs money. This process is used a lot in the United States because of low dumping prices.

2. The "gypsum producing process" technically her operational as the "gypsum/acid" process. This process has as side-product gypsum that can be used in the constructing sector. This lowers costs. But it is a wet system in which temperature of combustion gasses goes down to bout 60 ^{0}C, so re-heating is necessary. This is the only process used in the Netherlands in the sector of power plants.

3. The "regenerating process" in which the absorption material can be re-used. In the Netherlands only the "gypsum/acid" process is used. This was chosen on the basis of information on cost-effectiveness and problems connected to the three processes. There are two major sources of information on the costs of the installed abatement equipment in the Netherlands. They partly are not in line, but there are acceptable explanations for this. We get into that after presenting the facts:

First comprehensive study on abatement cost done by Wiersma

In the next table are the investment-costs of the three processes compared for several capacities (note: prices of 1984, source: Wiersma 1989):

Figure 34: Investments costs (million guilders 1984)

	150Mwe	300Mwe	450Mwe	600Mwe
Lime-sludge	20.4	39.7	58.1	71.3
Gypsum	22.4	47.8	71.3	89.6
Regenerative	40.7	73.3	103.9	119.2

Note: this figures are given for new plants. Existing plants require a 30 % larger Investment according to Wiersma. The table shows that there are some economies of scale in investment costs.

Next table gives the variable costs estimation for a 600 MWe plant that is used 6000 hours a year (68% used). Energetic return 40% (meaning 2150 Kcal/Kwh). Of course the variable costs predominantly depends on the % S in fuel used (Wiersma 1988).

Figure 35: Variable costs (million guilders 1984)

	0.5 % S	1.5 % S	2.5 % S	3.5 %S
Lime-sludge	6.07	18.21	30.36	42.5
Gypsum	1.03	3.09	5.15	7.21
Regenerative	2.07	6.21	10.35	14.49

When these key-estimates were used to estimate the yearly abatement costs it proved that the in the Netherlands used “gypsum/acid” wet process, the yearly abatement costs rise when low sulfur coal is used, the explanation for that is given later.

The next table gives the yearly costs for abatement equipment *only*, for several capacities (write of annuity, 25 years interest rate 4%, plant used 6000 hours a year -68% used-, Energetic return 40% (meaning 2150 Kcal/Kwh).

Figure 36: Total yearly costs (million guilders 1984)

	3.5 % S	2.5 % S	1.5 % S	0.5 %S
150Mwe	28	18	11	8
300Mwe	32	23	17	15
450Mwe	36	28	22	20
600Mwe	40	32	27	26

For the other two processes the same estimates are available. Remarkable outcome is that in these processes it pays to use medium-sulfur coals instead of high sulfur coals (Wiersma, 1989).

Second comprehensive study done by Bakema en Kroon

The second source of knowledge on costs is a study by Bakema en Kroon that was done for the Dutch National Exploration, a plan from the Ministry of Economic Affairs. Their estimates on prices were for the year 1985/1986. They tend to calculate with a bit shorter write-off periods, which is for abatement equipment better. Combined with the estimates of Wiersma the following numbers on the gypsum/acid process are perceived as more adequate:

Figure 37: Investments costs (million guilders 1985)

	150Mwe	300Mwe	450Mwe	600Mwe
Gypsum process, new plant (85% abatement)	24	52	77	97
Gypsum process, existing plant (85% abatement)	31	68	100	126
Gypsum process, new plant (95% abatement)	32	69	102	129
Gypsum process existing plant (95% abatement)	41	90	133	168

Also on the issue of the variable costs they make some adjustments. Most important they assume that to get rid of the gypsum, payments have to be made. This is a debatable assumption. Checking this contradiction learned that the gypsum is sold to the constructing sector, so the figures given are compensated for that (gypsum is sold, fl 40/ton).

Not debatable are the assumption on staff, that are in line with that of Wiersma and their substantial assumption on the maintenance costs (7% of the investment). Combined with the estimates of Wiersma the following numbers on the acid/gypsum process are probably more adequate, being of course the % S a relevant variable:

Figure 38: Variable costs, based on 1.27 % S-coal, plant 600 Mwe, used 6000 hours a year - 68% used-, Energetic return 40% (meaning 2150 Kcal/Kwh).

	150Mwe	300Mwe	450MWe	600Mwe
New plant (85% abatement)	3.9	7.8	11.6	15.5
Existing plant (85% abatement)	4.4	8.8	13.1	17.5
New plant (95% abatement)	4.6	9.3	13.9	18.5
Existing plant (95% abatement)	5.3	10.6	15.9	21.2

Because the actual capacity, production of electricity and %S in coal is known, the costs that are made can be estimated. Only “MC6” was operated on low sulfur coal without abatement equipment. The other power plants have different capacities, the quantities of electricity produced are different, the % Sulfur show some variation amounts. The capacity of the plant, the electricity produced and the % S in coal seem to be the factors that determine the costs.

Some final estimates on costs

The % S in coal has some serious impacts on costs. The differences/changes as presented don't seem to be that large at first sight. A closer look makes it clear why the electricity sector opened the discussion in an effort to enable them to use the emission space due to over-compliance, by raising the average %S in coal. The input of coal was in 1996 236 PJ. Based on the emission of SO2 without abatement, the average abatement in 1996, and the estimated price difference, it can be calculated that the increase of % S in coal from 0.7 in 1990 to 0.85 in 1996 saved the electricity sector about 30.000.000 guilders in 1996. The additional emissions caused can be calculated on the basis of the average abatement. The estimate is 2.2 kton. The cost saving for each ton additional SO2 emitted is therefor about 13600 Dutch guilders (prices 1988). This calculation is under the assumption that abatement is 92 %. If there is *no abatement equipment* installed, the saving is only 1088 Dutch guilders for every additional ton SO2.

The costs for abatement equipment installed can also be estimated on the basis of the study of Wiersma (1984):

Assumptions: A 600 Mwe power plant, that is used 68% (5256 use on full power basis), has an abatement percentage of 92%, fuel is coal that contains 0.85%S.

The estimated emission of SO2 for this plant without abatement is 26357 tons SO2, with abatement it is 2108 tons. The costs made for abatement are then calculated at 922 Dutch guilders/tons. This is close to the 1000 guilders for each ton that has been calculated by Bakema en Kroon (1988) on the basis of 85% abatement. On the basis of 95% abatement, they calculate 1050 Dutch guilders for every ton (Bakema en Kroon, 1988, p 36).

We are now able to estimate the costs related to abatement equipment in six plants.

We have knowledge on the amounts of electricity produced, the installed capacity, the use of capacity, the % S in coal and the abatement %. The abated tons SO2 and the costs can be calculated. In figure 39 the costs are given as total costs for the year 1996 and as costs for each ton SO2 that is abated by the plant. There are two versions given (I and II). Version I is based on figure 36, variety on capacity and on the percentage S in coal is taken into account. Taking variance in variable costs into account is not very useful, the differences are small, compare figure 35. The second version takes differences in variable costs due to the use of the plant and the variance in %S in coal into account, the estimates for variable costs are made on the basis of figure 37. The difference between "existing" and "new" has not been taking into account.

Figure 39: Estimated abatement costs of six electricity plants

Plant/capacity	GWh electricity 1996	Use **Of capacity %**	% S in coal	Emission no abatement **Gram/GJ**	Abatement percentage	Abated tons SO2 in 1996	Estima-ted total costs in 1996 I/II **(Millions Dutch guilders)**	Estima-ted abatement costs/ton SO2 **(Dutch guilders)**
G 13 602 Mwe	3192	60.5	0.87	661	93.6	31999	26.4/34.7	825/1084
MV 1 518 Mwe	3410	75.7	0.76	578	91.0	23416	22.5/29.6	960/1264
MV 2 518 Mwe	3406	75.6	0.76	578	91.1	23410	22.5/29.6	961/1264
BS 18 403 Mwe	2584	71.0	0.78	593	92.2	22829	18.7/24.6	1053/ 1385
A 81 645 Mwe	2449	43.4	0.94	714	92	20876	26.5/32.5	1269/1557
A 91 600 Mwe	4165	79.0	0.95	722	91.3	35473	26.2/38.8	739/1093

As shown by figure 39, a smaller plant like BS 18 may have smaller absolute abatement costs, the costs for each ton SO2 abated are relatively higher. The same is true for the intermediate plants MV1 and MV2. Plant A 81 shows that the capital costs for abatement equipment have large influences. When the use of the plant is low, abatement costs for each ton SO2 abated, raise strongly. For the interpretation of the absolute numbers, one has to take into account that these are 1984/1985 prices.

5. Productive efficiency

88/609/EEC did impose one additional restraint: For new coal-fuelled combustion plants, that were permitted before August 1th, 1988 the emission standard for NOx was lowered from 800 to 650 mg/m3 combustion gas. No technology was prescribed. The fact that large now is defined by the EU Directive as > 50 MW, and existing Dutch legislation defined it as >75 MW is irrelevant for the power plants.

In detail requirements on solid fuels and SO2 are as follows:

Figure 40: Requirements from Bees, the 200 mg demand is implemented by a renewal of Bees in 1992, before this date, the limit was 400. Some limits were made stricter at that time and the settlement between the government and SEP in the covenant was integrated in Bees

	Permit before 29/5/87	Permit between 29/5/87 and 1/1/90	Permit on or after 1/190
> 300 MW and still in use after 1994	Max. 400 mg SO_2/m3 + 85% desulfurication of combustion gasses , starting 1 december 1989	Max. 400 mg SO_2/m3 + 85% desulfurication of combustion gasses	Max. 200 mg SO_2/m3 + 85% desulfurication of combustion gasses
> 300 MW and not in use after 1994	Max. 0.8 % S in coals, starting 1/6/87 (coals 26 MJ/kg)	Max. 400 mg SO_2/m3 + 85% desulfurication of combustion gasses	Max. 200 mg SO_2/m3 + 85% desulfurication of combustion gasses
< 300 MW	Max. 0.8 % S in coals, starting 1/6/87 (coals 26 MJ/kg)	Max. 700 mg SO_2/m3	Max. 700 mg SO_2/m3

Therefore it is obvious that 88/609/EEC did not put new constraints on the power plants as far as SO2 is at stake. The Air Pollution Act (WLV) and the AMvB Bees 1987/1991 that indeed do impose constraints, open the possibility for permitting authorities to lower the maximum 1.2% S in coal. This limit % S in coal in regulated in the AMvB Sulfur-percentage Fuels that first came into use in 1974 and was changed several times. In principle provinces could go as low as 0.3 in their permits. But when the covenant was negotiated the outcome was that provinces were not gonna issue any additional demands as long as the electricity sector performed to a level as was agreed upon.

Still a closer look at the regulation makes clear that with the coal-fired electricity grid the degrees of freedom were not that large. The Plan of action drawn up by the Sep had to take into consideration the constraints from existing regulation. The covenant did impose additional constraints on the sector as a whole, not on individual plants. Still existing regulation as mentioned imposed constraints on individual power plants.

Of course the expected pattern can be observed. The only power plant without abatement-equipment MC6 “Maascentrale” was fired by low sulfur coal in 1996. The others were fired in 1996 on coal with a higher % S in combining this with a wet washer that performed at least 85% abatement (compare figure 36). In 1996 the % S in coal was in average 0.85%

The trend to perform more than the required 85% abatement can be understood in the system of cost-price compensation that was applied within the sector and coordinated by the SEP. Recently the energy market liberalized. The experts observe that the power plants nowadays try to fill the allowed level of emission, trying to lower costs. They tried it before while implementing the covenant, pressure form the government prevented it from being applied at large scale, still in the year 1996 the average % S in coal was high compared to previous years. The upper level of S in coal allowed is 1.2%.

On informative events the knowledge of the threat of stricter was important as a driver. For the implementation of the covenant the knowledge/information of SEP in the coordinated structure was important. Starting point for the Sep was cost-effectiveness when they developed the plan of action, as they were obliged to by the covenant. They used their normal operating and counting program. All power plants are in and the program is used for balancing the cost-prizes of electricity producers. This is necessary of course in a system in the Sep decided when every individual plant has to be switched on or switched of. On the basis of a scenario until the year 2000, the necessary abatement was known. The four electricity-producing companies indicated what they could do to decrease emissions. After a first shake out, detailed costs estimates were made. The openness of the process was enormous according to the respondents from the Sep. A crucial factor in this was of course the existence of the cost pooling mechanism[2].

Still we have to keep in mind that the Sep could not prepare the measures in total freedom. The fact that the covenant included no additional stricter regulation, this does not mean that existing regulation was not valid. The constraints from existing regulation are discussed in the paragraph on productive efficiency.

[2] The Covenant concerning the reduction of SO2 and Nox emissions, Ellis Brand, Enschede, June 1999.

6. Administrative cost

6.1. Goverments

At the Ministry of Housing, Physical Planning and Environmental Affairs, two full-time staff-members are employed with the regulation, implementation and monitoring of Large Combustion Plants. This includes the covenant and the monitoring of the covenant. A reasonable estimate would be that about 25 % is spend on power plants being 0.5 full-time staff member.

In every of the twelve provinces one full time staff-member is employed with the regulation, implementation and monitoring of Large Combustion Plants (12 x 1). Off course more than 12 people can be involved. A reasonable estimate would be that about 25 % of this time is spend on power plants. One should however takes into account that a lot of this time is spend on other issues than just the emissions of SO2 and Nox. The work comprehends the whole permit of the electricity plant and deals with quite a number of aspects like noise, vibrations, smell, transportation, waste-water in the sewer.

This estimate can be cross-checked by some available estimates for these kind of plants.

Benchmarks are that an "integral permit" takes 112 hours work, an integral monitoring/enforcement effort takes 39 hours, taking care of a complaint takes 5 hours (VNG, 1995). An "Integral permit" comprehends as mentioned before, a lot more than just air-emissions. The permit will be readjusted but normally has a life span of about 10 years. The frequency of monitoring and enforcement efforts is normally in between the range from twice a year to once every two years. The lower limit is in this estimate 30.7 hours, the upper limit 89.2 hours.

A full work year is about 1800 hours, there are about 100 power units, so on central level about 9 hours are spend on every power plant and on the level of provinces about 54 hours (second estimate: 30.7 - 89.2 hours) are spend on every power plant. The effort for only SO2 emissions is a lot smaller.

6.2. Power plants

The SEP is not able to estimate the time spend on the covenant and the four progress reports. Also the drawing of the Plan of action cannot be estimated in hours. The reason is that these tasks were performed in the context of operational/coordinating management over the electricity sector.

In the sector estimates of the administrative costs involved deal with this as being variable costs. For a plant with a capacity of 600 Mwe, for every hour of production 0.54 hour of indirect administrative costs are calculated. For a 600 Mwe plant that is used for 6000 hours this will mean about 3240 hours. In total this would lead to about 21000 man-hours for all coal fired plants together, if they were used for the 68% of the time Still these are very rough estimates that could include some of the technical management of the abatement equipment. Registration of emissions of SO2 usually was done by the power plants. Either by continuos measurement or by, in small plants, calculations on the basis of monitoring the % sulfur in coal.

7.Conclusions

In the period 1990-1996 large efforts for the abatement of SO2 and Nox have been made in the Netherlands

The abatement efforts were not causal linked to the European Directive 88/609/EEC.

There was already substantial regulation on SO2 and Nox emissions of Large Combustion Plants in the Netherlands.

National implementation as far as integrating 88/609/EEC into national regulation is at stake, was just a formal bureaucratic exercise. Only one emission limit was changed. This concerned a minor change.

In the late eighties environment was an important political issue and an important public issue in the Netherlands. Even a cabinet fell on a minor environmental relevant measure, elections afterwards were also dominated by environmental issues.

The drivers for the efforts in the late eighties and early nineties were the Dutch national policy on acidification and, related the political and public interest in environmental issues in the Netherlands.

A firm Dutch government formulated the expected efforts for several groups (refineries, power plants, industry, agriculture and traffic to fight acidification). Only the policy instruments were debatable.

The electricity sector was threatened by stricter regulation

For the electricity sector this was a driver for willing to reach for a covenant with the central government; the inevitable alternative would have been regulation leaving little flexibility.

Regulation was perceived by the electricity sector as a risk: how were the efforts going to be allocated? The electricity sector aimed at goals at the aggregate level. Regulation addresses the individual power plant.

The believe was that cost-effectiveness would be better in case of the covenant. Efforts to lower the ambition of central government were without results.

In 1990 the covenant was signed June 1990. The content was a sharp decrease of SO2 emissions and NOx emissions until the year 2000. Existing regulation would stay in use, stricter limits were not going to be issued as long as the electricity sector performed as they agreed upon.

The covenant was satisfying for both government and electricity sector. A substantial reduction of SO2 and NOx emissions was combined with freedom for the electricity sector to implement in the most cost-effective way.

The goals were on the aggregate level of the sector and not on the level of individual electricity plants. The already longer existing regulation was the only constraint on the individual level. There was no new constraint put on the individual plant.

The electricity sector had to draw up a plan of action in order to implement the covenant.

Law organized the electricity sector. The Sep, the "trade association" of the electricity sector, was the central player.

The Sep coordinated the electricity supply the public sector, operated the operational switch on and switch of off of individual power plants. The four large electricity producing companies in the Netherlands owned the Sep.

The success of the plan of action is found in the close cooperation between the Sep and the four large electricity producers. The fact that the Sep runs a system of cost pooling was essential for the openness during the drawing of the plan of action.

The Sep made a first rough draw on the basis of a scenario until 2000, the electricity producers than brought up alternatives. After a first shakeout, detailed cost studies were done.

The environmental effects of the covenant were large. SO2 emissions decreased from 43.7 ktons in 1990 to 18.7 ktons in 1996.

To what extends this is a result of the covenant as policy instrument, can be doubted. The context in which parties agreed upon the covenant was quite clear: it was either the covenant or regulation.

So the explanation is to be found in the covenant in a context of the thread of regulation. For new plants existing regulation required substantial abatement efforts. The general conclusion is that there are no reasons to deny that the covenant was the prime driver for changes made, still existing regulation and the avoidance of the alternative instrument are important factors to keep in mind when analyzing the changes made.

Finally SO2 emissions could have been even less when the new coal-fired plants would not have been built. The energy-policy on fuel differentiation and the strategy of Sep to secure cheap fuels explain the building of these new plants. The additional SO2 emissions created no problems, for the NOx emissions it made no substantial difference.

There was some over-compliance on SO2 emissions, the electricity sector undertook some effort to fill up this room and decrease costs by (1) lowering the effectiveness of the abatement equipment and (2) using coals with more sulfurs. The first proposal is not really exercised, the second is. Both decrease costs.

The over-compliance was caused by a conservative estimate of the abatement equipment, the use of low sulfur coal, the switch on and switch of policy on coal fired plants and the closing down of one coal plant years before schedule. It is better not to speak about over-compliance but about premature compliance to the goals set for 2000.

The individual abatement patterns of power plants diver substantially. The reason for this is that there are different measures taken.

Six old coals fueled plants without abatement equipment were closed (total capacity 985 Mwe), two new coals fired plants with abatement equipment (total capacity 1200 Mwe) were built. The average performance of the SO2 abatement equipment was improved a bit by maintenance and in some years coal that was lower on sulfur was burned.

The % S in coal has some serious impacts on costs. The electricity sector opened the discussion to use the space available due to over-compliance in order to raise the average %S in coal. It is calculated that the increase of % S in coal from 0.7 in 1990 to 0.85 in 1996 saved the electricity sector about 30.000.000 guilders in 1996. The additional emissions caused can be calculated on the basis of the average abatement. The estimate is 2.2 kton.

The cost saving for each ton additional SO2 is therefor about 13600 Dutch guilders (prices 1988). This calculation is under the assumption that abatement is 92 %. If there is *no* abatement equipment installed, the saving is only 1088 Dutch guilders for every additional ton SO2.

The costs for abatement equipment installed can also be estimated.: For six coal fired plants the available data made it possible to make estimates of the costs for every ton SO2 abated by the abatement equipment.

There are two versions of this calculation given. The difference is the way the variable costs are valued. The first estimate results in average costs for each ton SO2 abated of 825-1269 Dutch guilders. This estimate should be considered a bit low.

The second estimate result in average costs for each ton SO2 abated of 1084-1557 Dutch guilders (Prices 1984/1985). Smaller plants in the population have lower absolute abatement costs, the costs for each ton SO2 abated are relatively higher. The same is true for the intermediate plants. When the use of the plant is low, abatement costs for each ton SO2 abated, raise strongly.

The European Directive 88/609/EEC did not put new constraints on the power plants.

One should keep in mind that the Sep could not prepare the measures in total freedom. The fact that the covenant included no additional stricter regulation, this does not mean that existing regulation was not valid.

Still a closer look at the regulation makes clear that with the coal-fired electricity grid the degrees of freedom were not that large.

The Plan of action drawn up by the Sep had to take into consideration the constraints from existing regulation. The covenant did impose additional constraints on the sector as a whole, not on individual plants. Still existing regulation imposed constraints on individual power plants.

For the implementation of the covenant the knowledge/information of SEP in the coordinated structure was important. Starting point for the Sep was cost-effectiveness when they developed the plan of action, as they were obliged to by the covenant. They used their normal operating and counting program. All power plants are in and the program is used for balancing the cost-prizes of electricity producers. This is necessary of course in a system in the Sep decided when every individual plant has to be switched on or switched of.

On the basis of a scenario until the year 2000, the necessary abatement was known. The four electricity-producing companies indicated what they could do to decrease emissions. After a first shake out, detailed costs estimates were made. The openness of the process was enormous according to the respondents from the Sep. A crucial factor in this was of course the existence of the cost pooling mechanism.

On administrative costs made by the government trustworthy information is present. About 0.5 full-time staff member was spend on central level and about 3 full time staff-members was spend on provincial level. There are about 100 power plants, so 9 hours each year was spend on every power plant and on the level of provinces about 54 hours are spend on every power plant. On the level of provinces there is a second estimate available with a range of 30.7 to 89.2 hours for every power plant. The effort for only SO2 emissions is a lot smaller.

On administrative costs for the *coal fired* power plants the estimates are less trustworthy. There is only a rough estimate of 3240 hours each year for 600 Mwe plants that could include some of the technical management of the abatement equipment

References

Expert-knowledge is used of:

Ing. H.W Holtring, Ministry of Housing, Spatial Planning and the Environment, Board Air and Energy

Ing. L de Jonge, Ministry of Housing, Spatial Planning and the Environment, Board Air and Energy

Ir. B.A. Kleinbloesem, N.V. Sep

Dr. J. van der Kooi, N.V. Sep

Drs. C. Luttikhuizen, Ministry of Housing, Spatial Planning and the Environment, Waste Board

Ir. E.J.M. van der Werf, Province Gelderland

Literature

Arentsen, M.J., R.W. Kunneke and H.C. Moll, The Dutch electricity reform reorganization by negotation, in: A. Midtun (ed), *Electricity systems in transition*, 1997.

Bakema. G.F. and P. Kroon. *Vermijden of bestrijden? Emissies en kosten van emissiebeperking van SO2, Nox en stof tot 2010, behorend bij de Nationale Energieverkenning 1987*, Energiestudiecentrum, ESC-44, Petten, 1988

Besluit emissie-eisen stookinstallaties Wet inzake de luchtverontreiniging; Stb. 1987, 164.

Besluit emissie-eisen stookinstallaties Wet inzake de luchtverontreiniging; Stb. 1991, 354.

Besluit emissie-eisen stookinstallaties Wet inzake de luchtverontreiniging; Stb. 1992, 451.

Brand, E.M.L., *The Covenant concerning the reduction of SO2 and Nox emissions*, Enschede, June 1999

Eames, M., *IMPOL Operational Guidelines and Indicators for the LCPD Case Study (second draft), Brighton*, January 1999

Keizer, V.G., Nederlands verzuringsbeleid na 2000, in: *Lucht*, 1997, nr.2 ., juni 1997.

Ministry of Housing, Spatial Planning and the Environment, *Bestrijdingsmogelijkheden van verzurende procesemissies in Nederland*,, (Publicatiereeks Lucht & Energie nr. 101) Den Haag, 1992

Ministry of Housing, Spatial Planning and the Environment, *Leidraad Besluit emessie-eisen stookinstallaties milieubeheer A (BEES A*), (Publicatiereeks Lucht & Energie nr. 111) Den Haag, 1993

Ministry of Housing, Spatial Planning and the Environment, *Kosteneffectiviteit van milieumaatregelen in de industrie "Beschrijving van de methodiek", deel A* (Publicatiereeks Lucht & Energie nr. 119) Den Haag, 1995

Ministry of Housing, Spatial Planning and the Environment, *Kosteneffectiviteit van milieumaatregelen in de industrie "Vaststellen referentiekader", deel B* (Publicatiereeks Lucht & Energie nr. 120) Den Haag, 1995

Ministry of Housing, Spatial Planning and the Environment, *Eindrapportage. Vervolgonderzoek kosteneffectiviteit van milieumaatregelen in de industrie "Vaststellen referentiekader", deel B* (Publicatiereeks Lucht & Energie nr. 126) Den Haag, 1995

Ministry of Housing, Spatial Planning and the Environment, *Emissions from Large Combustion Plants in the Netherlands in 1990 and 1992*, (Publikatiereeks Emissieregistratie nr. 7) Den Haag, 1993.

Ministry of Housing, Spatial Planning and the Environment, *Emissions from Large Combustion Plants in the Netherlands in 1992 and 1993*, (Publikatiereeks Emissieregistratie nr. 25) Den Haag, 1995.

Ministry of Housing, Spatial Planning and the Environment, *Emissions from Large Combustion Plants in the Netherlands in 1995*, (Publikatiereeks Emissieregistratie nr. 36) Den Haag, 1997.

N.V. Samenwerkende electriciteitsproduktiebedrijven, Plan van aanpak ter uitvoering van het Convenenant over de bestrijding van SO2 en Nox, Arnhem, 1991

N.V. Samenwerkende electriciteitsproduktiebedrijven, 1e Voortgangsrapportage betreffende de Bestrijding van SO2- en Nox-Emissies van de Electriciteits-produktiebedrijven in de jaren 1990 en 1991 in het kader van het Convenant, Arnhem, 1992

N.V. Samenwerkende electriciteitsproduktiebedrijven, 2e Voortgangsrapportage betreffende de Bestrijding van SO2- en Nox-Emissies van de Electriciteits-produktiebedrijven in de jaren 1992 en 1993 in het kader van het Convenant, Arnhem, 1994

N.V. Samenwerkende electriciteitsproduktiebedrijven, 3e Voortgangsrapportage betreffende de Bestrijding van SO2- en Nox-Emissies van de Electriciteits-produktiebedrijven in de jaren 1994 en 1995 in het kader van het Convenant, Arnhem, 1997

N.V. Samenwerkende electriciteitsproduktiebedrijven, 4e Voortgangsrapportage betreffende de Bestrijding van SO2- en Nox-Emissies van de Electriciteits-produktiebedrijven in de jaren 1996 en 1997 in het kader van het Convenant, Arnhem, 1998

Second Chamber of Parlement, Multi-Year Program Air Pollution 1985-1986, TK 1985-1986, 18605 nrs 1-2.

Second Chamber of Parlement, Bestrijdingsplan Verzuring, TK 1988-1989, 18225, nr.31.

VNG, Kaderplan Gemeentelijk Milieubeleid, VNG uitgeverij, Den Haag, 1995.

Wiersma, D., De efficientie van een marktconform milieubeleid. Een uitwerking van de SO2 emissiebestrijding van de nederlandse electriciteitssector, 1989, ISBN 90-72015-41-X