

Weidner, Helmut

Book — Digitized Version

Air pollution control strategies and policies in the Federal Republic of Germany: laws, regulations, implementations and principal shortcomings

Provided in Cooperation with:

WZB Berlin Social Science Center

Suggested Citation: Weidner, Helmut (1986) : Air pollution control strategies and policies in the Federal Republic of Germany: laws, regulations, implementations and principal shortcomings, ISBN 3-924859-17-5, Edition Sigma, Berlin

This Version is available at:

<https://hdl.handle.net/10419/112251>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



WZB-Open Access Digitalisate

WZB-Open Access digital copies

Das nachfolgende Dokument wurde zum Zweck der kostenfreien Onlinebereitstellung digitalisiert am Wissenschaftszentrum Berlin für Sozialforschung gGmbH (WZB). Das WZB verfügt über die entsprechenden Nutzungsrechte. Sollten Sie sich durch die Onlineveröffentlichung des Dokuments wider Erwarten dennoch in Ihren Rechten verletzt sehen, kontaktieren Sie bitte das WZB postalisch oder per E-Mail:

Wissenschaftszentrum Berlin für Sozialforschung gGmbH
Bibliothek und wissenschaftliche Information
Reichpietschufer 50
D-10785 Berlin
E-Mail: bibliothek@wzb.eu

The following document was digitized at the Berlin Social Science Center (WZB) in order to make it publicly available online.

The WZB has the corresponding rights of use. If, against all possibility, you consider your rights to be violated by the online publication of this document, please contact the WZB by sending a letter or an e-mail to:

Berlin Social Science Center (WZB)
Library and Scientific Information
Reichpietschufer 50
D-10785 Berlin
e-mail: bibliothek@wzb.eu

Digitalisierung und Bereitstellung dieser Publikation erfolgten im Rahmen des Retrodigitalisierungsprojektes **OA 1000+**. Weitere Informationen zum Projekt und eine Liste der ca. 1 500 digitalisierten Texte sind unter <http://www.wzb.eu/de/bibliothek/serviceangebote/open-access/oa-1000> verfügbar.

This text was digitizing and published online as part of the digitizing-project **OA 1000+**. More about the project as well as a list of all the digitized documents (ca. 1 500) can be found at <http://www.wzb.eu/en/library/services/open-access/oa-1000>.

**Weidner: Air Pollution Control
Strategies and Policies in the F.R. Germany**

WISSENSCHAFTSZENTRUM BERLIN FÜR SOZIALFORSCHUNG

Forschungsschwerpunkt Umweltpolitik
(Internationales Institut für Umwelt und Gesellschaft)

Research Unit Environmental Policy
(International Institute for Environment and Society)

Editorial Board:

Karl W. Deutsch
Meinolf Dierkes
Egon Matzner
Frieder Naschold
Udo Ernst Simonis

Helmut Weidner

**Air Pollution Control Strategies and Policies
in the Federal Republic of Germany**

Laws, Regulations, Implementation
and Principal Shortcomings



CIP-Kurztitelaufnahme der Deutschen Bibliothek

Weidner, Helmut:

Air pollution control strategies and policies in the Federal Republic of Germany : laws, regulation, implementation and principal shortcomings / Helmut Weidner. Wissenschaftszentrum Berlin für Sozialforschung . - Berlin : Ed. Sigma Bohn, 1986.

ISBN 3-924859-17-5

© Copyright 1986 by edition sigma rainer bohn verlag, Berlin.
All rights reserved. No part of this book may be reproduced or copied in any form or by any means --graphic, electronic, or mechanical, including photocopying, recording, taping, or information and retrieval systems-- without prior written permission from the publisher.

Printing and binding: WZB

Printed in Germany

TABLE OF CONTENTS

PREFACE	7
ACKNOWLEDGEMENT	9
I AIR POLLUTION PROBLEMS: DEVELOPMENT AND PRINCIPAL FEATURES	11
1. General Indicators	11
1.1 General national indicators	11
1.2 International features	14
2. Emissions of Major Pollutants	17
2.1 Emission source inventory	18
3. Ambient Air Quality (Immission)	23
3.1 Monitoring network	23
3.2 Reporting on monitoring results	25
3.3 Monitoring results	29
3.4 Special features of air pollution problems	30
4. Future Trends of Air Pollution Problems	34
4.1 Trends in emissions from stationary sources	34
4.2 Mobile sources	36
5. Air Pollution Damage and Its Costs	36
5.1 Public health	37
5.2 Forests and plants	39
5.3 Rivers, lakes and soil	44
5.4 Materials	45
5.5 Economy in general	46
II A BRIEF HISTORY OF AIR POLLUTION CONTROL POLICY IN THE FEDERAL REPUBLIC OF GERMANY	49
1. The Development of Programmes and Legislation	49
2. Social, Economic and Political Developments and Their Influence on Air Pollution Control Policy	53
III PRESENT AIR POLLUTION CONTROL SYSTEM: LAWS, REGULATIONS, STANDARDS, APPROACHES AND ORGANISATION	59
1. Introduction	59
2. Responsibilities and Organisational Structures	60
2.1 Federal level	62
2.2 State level	65
2.3 Local level	66
2.4 Other institutions	66
2.5 Courts	67

3.	Laws and Regulations	68
3.1	Overview	69
3.2	Basic standards, regulations, and approaches in air pollution control	72
3.2.1	Facility-related measures	76
3.2.2	Area-related measures	82
3.2.3	Product-related measures	88
3.2.4	Measures related to mobile sources	90
3.2.5	General supplementary and supporting measures	93
IV	DEVELOPMENTS IN AIR POLLUTION ABATEMENT TECHNOLOGY AND RELATED EXPENDITURES	99
V	ALTERNATIVE AIR POLLUTION CONTROL STRATEGIES AND INSTRUMENTS	109
1.	Shortcomings of West German Clean Air Policy Before 1983	109
2.	Alternatives	114
VI	RECOMMENDATIONS	121
1.	Areas for Further Research, Monitoring and Assessment	121
2.	Recommendations	122
VII	CONCLUSION	125
VIII	LITERATURE	131

PREFACE

At the Science Center Berlin, research on clean air policy has had a long tradition. At a time when most experts and citizen action groups regarded the problem of SO_2 as being solved or of lesser importance, the IIUG initiated a long-term, international comparative study on standard setting and implementation in the field of sulphur dioxide control policy. The results of this study, the most comprehensive one carried out to date anywhere, on basic strategies and shortcomings of air pollution control policy of major emitter countries in the European Community, have played a decisive role in calling the serious shortcomings of clean air policy to the attention of the scientific community and the general public. The discussion about 'Waldsterben' (dieing forests) which emerged in the early 1980s showed that the choice of SO_2 as the object of our study was correct. Our studies on clean air policy in Japan also attracted considerable attention and have substantially influenced the present discussion about improving air pollution control policy in the Federal Republic of Germany.

The experience accumulated over several years of research at the IIUG in the field of clean air policy may have attracted the "World Commission on Environment and Development", Geneva, to commission one of this institute's fellows to carry out a study on pollution programmes and strategies in the Federal Republic of Germany. The results are compiled in this book. It provides a comprehensive overview of the development of clean air policy in this country from the early 1970s up to early 1986. The laws, regulations, standards and administrative structures are systematically presented and analyzed with respect to their advantages and shortcomings. An exten-

sive section on emissions, air quality trends and damages through major air pollutants using precise data, shows the real achievements of clean air policy measures. It may appear surprising to some readers that although West Germany's clean air standards are the most comprehensive with regard to legal regulations, in comparison to other European countries, and the administrative expenditures are exceedingly high, the reduction in harmful pollutants is still only minimal. The reasons are concisely and clearly brought out in this book. Therefore, it should be of particular interest to countries just beginning to take effective action in air pollution control, in order to eliminate similar mistakes, countries often oriented toward the regulatory approach of the Federal Republic of Germany.

The book also illustrates that since 1983 new laws and regulations have brought about decisive improvements in West German clean air policy so that we can assume that in the midterm, SO_2 and NO_x emissions from stationary sources will be considerably reduced. However, it is also shown that, despite these improvements, the basic feature of air pollution control in West Germany is still the "react and cure" and not an "anticipate and prevent" approach.

Almost all European countries have the same fundamental deficit in their approach, as can be seen in the preliminary work on a further study for the "World Commission on Environment and Development". This study on air pollution control policies and their effects in about 20 European countries will appear with this publisher in Winter 1986. It is our hope, that it will provide a scientific basis and new proposals for the urgently needed internationally coordinated measures in the field of clean air policy.

Berlin, July 1986

Udo E. Simonis
Director IIUG

A C K N O W L E D G E M E N T

This study was commissioned and partly funded by the World Commission on Environment and Development, Geneva.

I am indebted to Dagmar Kollande and Chris Reinelt (IIES/ Science Center) who took great pains in upgrading my English syntax and style. I am also grateful to Kazu Kato (World Commission on Environment and Development) and Dieter Deumling (Hatzfeldt - Wildenburg'sche Kammer) for stimulating and helpful comments on a former version of the study. Any remaining errors or omissions are entirely my responsibility.

Berlin, July 1986

Helmut Weidner

I AIR POLLUTION PROBLEMS: DEVELOPMENT AND PRINCIPAL FEATURES

1. General Indicators

This sub-section shall briefly provide central statistics and information on the Federal Republic of Germany and its international setting, for a better understanding and assessment of air pollution problems facing this country.

1.1 General national indicators

With about 62 million inhabitants and a total area of approximately 250,000 square kilometers, the FRG has an average population density of 248/sq.km. Compared to the other member countries of the EEC, the FRG ranks third (after the Netherlands and Belgium) with its population density. An intra-national comparison among the eleven federal states shows large differences in population density, urban agglomerations and industrial structure. The states of North Rhine-Westphalia and Berlin have the largest agglomerations of industry and population and, correspondingly, very high pollution loads. In general, and compared to international standards, the FRG belongs to the densely and highly industrialised countries.

Because most of the air pollution problems in the FRG are the result of combustion processes, the development of energy trends and changes in energy structure are of interest. The energy supply pattern in the FRG is characterised by a high percentage of mineral oil (ranking first) and coal (ranking second). Compared to other countries coal (which involves more technical problems for pollution abatement measures) has a very strong "political position" because of the political influence of the coal mining industry and coal miners unions on energy policy decisions. This led in 1980 to a so-called century treaty between the power generating industry and the coal mining companies to increase the

percentage of coal used for energy production until 1995. Since 1970, there have been significant shifts in energy consumption patterns resulting in an increase of natural gas and nuclear energy. Further, the growth rates in energy consumption levelled off. In 1974, energy consumption as well as the final energy demand decreased for the first time. For the latter, this trend remained continuous. The highest energy saving rates have been achieved by industry whereas the energy consumption in the traffic sector increased in spite of improvements in the fuel economy of individual cars owing to the large increase in the total number of motor vehicles. In the household sector (including small businesses) the trend remained about the same. Although the proportion of nuclear energy production increased (presently it accounts for about 27% of electricity production), it is not to be expected that the rather small growth rates of nuclear energy will significantly contribute to a decline in emissions of air pollutants because of the long planning, authorisation and construction time for new nuclear power plants due to public opposition. Figure 1 shows the energy consumption trend by fuel type since 1970.

Major factors contributing to these changes in energy supply and demand patterns include higher energy prices, technological changes, changes in consumer habits, promotion of energy saving measures and economic recession. The latter affected the emission of air pollutants in general. Especially "high pollution industries", like the iron and steel industry, suffered from economic recession and declining demands. This led to a decrease of particulate and gaseous discharges. The overall positive effects of economic recession on discharges of air pollutants have to be considered when evaluating environmental policy impacts because they cannot be accounted for as a success of environmental policies. On the other hand, the economic recession, especially since the oil price crisis of 1973, has hampered the development of needed environmental programmes and the enforcement of existing ones: environmental policy increasingly came

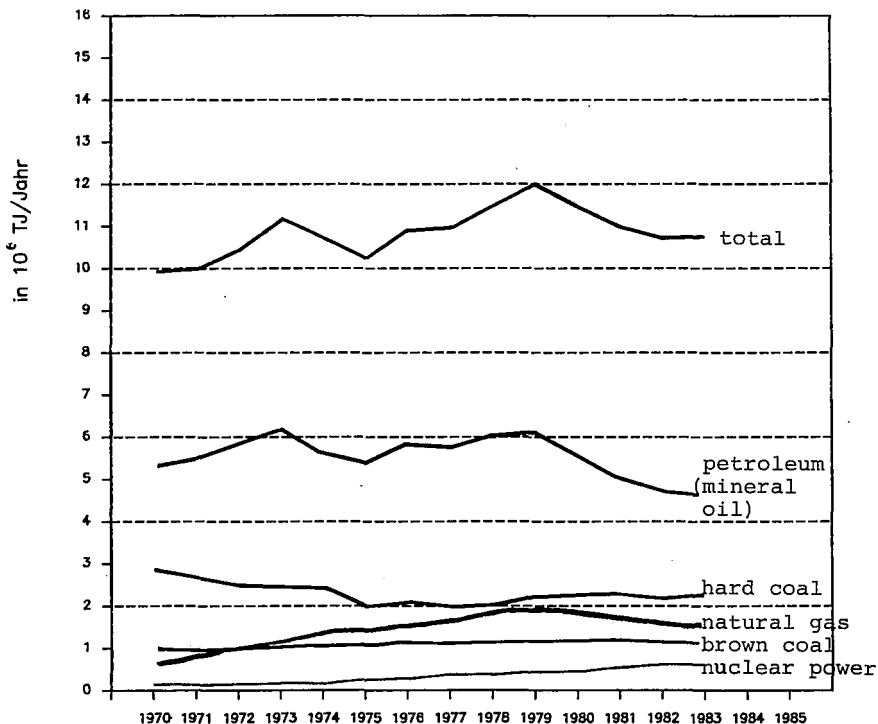


Figure 1. Energy consumption in the FRG by sources, 1970-1983. (source: Umweltbundesamt 1984).

under pressure by massive reproaches to be responsible for contributing to inflation, unemployment, declining economic growth and preventing technological progress. These challenges, in fact, slowed down the progress in air pollution control policy until recently, although no reliable data were provided to support the argument that the air pollution control programmes had such unfavourable macroeconomic impacts.

The climatic conditions in the FRG are of a moderate continental type with moderately warm summers and rather cold winters. Correspondingly, air pollution problems increase in the winter (heating periods). Furthermore, there are quite often critical weather situations in which the horizontal

and vertical exchange of air is reduced to such a degree that harmful concentrations of pollutants arise (London type smog). Evidence is also increasing that photochemical smog situations (Los Angeles type smog) are possible in certain regions despite moderate temperatures in the summer.

Emissions of air pollutants by car exhaust have increased over the past decade. This upward trend is due to the weak control requirements for motor vehicles which have not kept pace with increases in the number and use of vehicles. Since 1950 the number of vehicles has increased more than tenfold: from 2 million in 1950 to 27 million in 1980. Figure 2 shows the increase by the type of vehicles since 1975.

1.2 International features

The FRG is thoroughly involved in Europe's complex air pollution problems. It is not only a major exporter of air pollutants, but also a recipient of substantial quantities of imported pollution. Particularly significant is the long-range migration of sulphur dioxide, nitrogen oxides, and the products of SO_2 and NO_2 oxidation--the main causes of acid rain. The other transformation products are ozone and photochemical oxidants. Almost all European countries are considerably affected by air pollutants from other countries. Correspondingly, an effective national air pollution policy also requires international cooperation. This is especially necessary for combatting SO_2 . The FRG belongs to the largest SO_2 producers in western Europe. About one-half of the FRG's sulphur emissions are transported to Scandinavia, eastern Europe, and other countries. According to estimations by the ECE in 1981 (EMEP programme), Scandinavian countries receive the following amounts of SO_2 depositions from the FRG (in 1000 metric tonnes per year): Denmark 27, Finland 26, Norway 48, and Sweden 84. Foreign sulphur emissions, originating mainly in France, the United Kingdom, the German Democratic Republic and Belgium, contribute to about one-half to sulphur emissions deposited within the FRG's borders according to estimations of the German Federal Government.

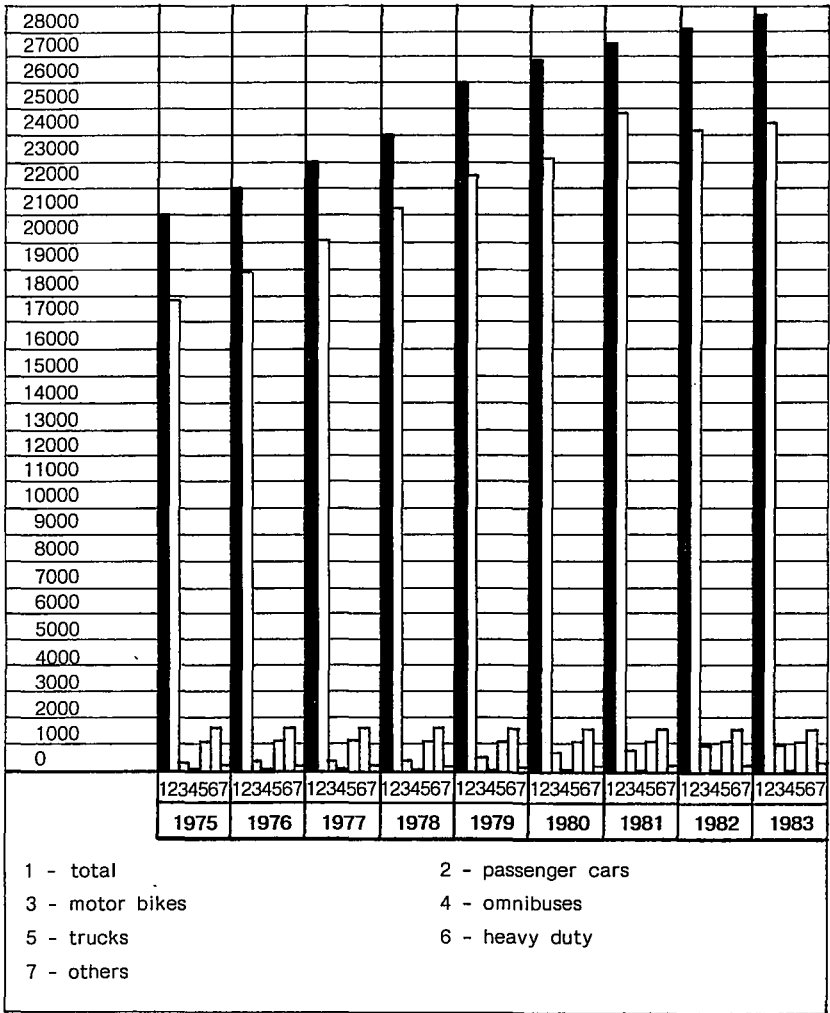
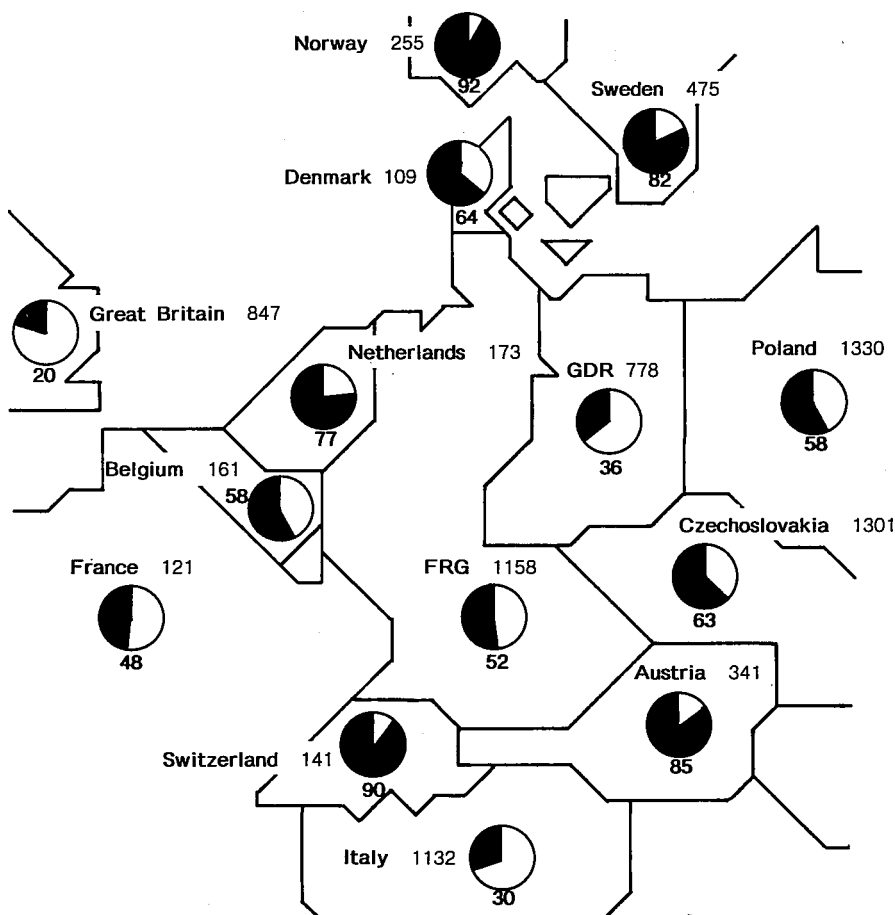


Figure 2. Motor vehicles: growth rate (in 1,000), 1975-1983 (source: Umweltbundesamt 1984).

Figures 3 and 4 show the source of deposition of sulphur in Europe and the export-import relationship for sulphur among the FRG and other European countries.



Belgium 161

Average Monthly Deposition of Sulphur (100 metric tonnes)



Percentage of deposition received from other countries

SOURCE:

UNECE - EMEP Programme 1983

Figure 3. Source of 1980 deposition of sulphur in Europe (source: Environmental Resources Ltd. 1983)

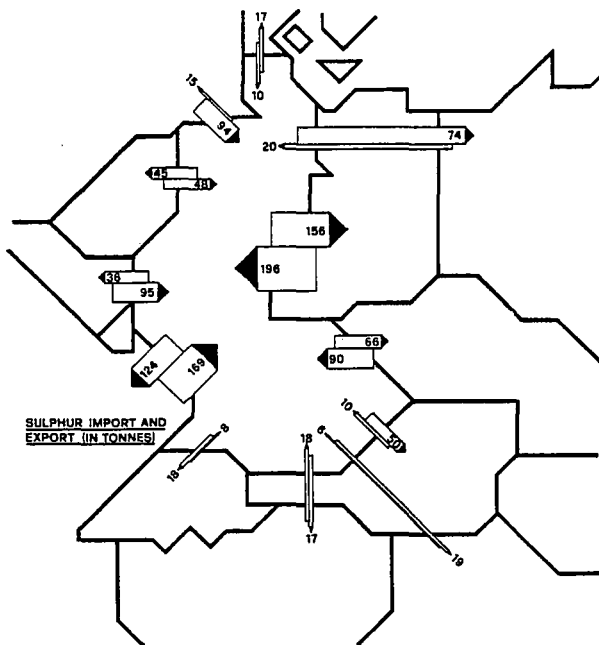


Figure 4. Deposition of sulphur in Europe: relationship between the Federal Republic of Germany and other countries - import to and export from the FRG (in tonnes sulphur). Note: 1 t sulphur = 2 t SO₂ (source: GLOBUS; Rat der Sachverständigen für Umweltfragen 1983)

2. Emissions of Major Pollutants

In general, the total amount of emitted air pollutants is identified by calculation, not by direct monitoring at the source. Only in rare cases, primarily larger combustion plants, does direct and continuous monitoring of some air pollutants (SO₂, NO_x, dust) take place. In all other cases, emission inventories result from calculations based on energy, raw material and production data related to so-called emission factors. Thus, these calculations leave a certain range of uncertainty which is lower for major air pollutants than for the quantitatively minor, but more harmful ones. It is generally agreed that emission monitoring should be improved because reliable, valid data on the amounts of emissions and their trends are preconditions for a rational air pollution control policy.

2.1 Emission source inventory

Table 1 shows the development of major air pollutants and the relative contribution by major emitting sources. Figures 5 to 9 show, for the period of 1966 to 1982, that the total amount of SO₂ emissions has remained nearly stable, whereas the emissions of NO_x and hydrocarbons (CH) have increased; the emissions of dust and carbon monoxide (CO) have dropped; the relative (and partly also the absolute) contribution of power plants to SO₂ emissions and of traffic to NO_x and dust emissions has increased.

In contrast to the major (conventional) air pollutants, which are rather few in number and relatively well-documented, the "unconventional" trace pollutants are numerous and not controlled systematically although many have been the subject of controversies about their environmental and health impacts. Of prime concern are substances known or suspected to cause chronic defects such as cancer, genetic changes and deformities at birth. The following substances are included in these unconventional pollutants: inorganic arsenic, asbestos, benzene, mercury, vinyl chloride, cadmium, halogens and their organic compounds, dioxins, ethylene, formaldehydes, lead, benzo(a)pyrene, chloroflourocarbons and PCBs, to name just a few. There is still considerable uncertainty about the amount of emissions of these pollutants and their effects. There are only more or less rough estimates about the amount of emissions of halogens, some organic compounds which are known to be especially toxic, and for emissions of toxic metals and other toxic trace elements such as lead, mercury, cadmium, arsenic, beryllium, which have been in the focus of studies with respect to their effects on human health. Many of them are emitted by mobile sources, power plants, industry and, especially, waste incineration plants.

The relative contribution of the several emission sources to air pollution in terms of concentration values and to detrimental and harmful effects for the environment and human

TABLE 1

TOTAL EMISSIONS OF SO₂, NO₂, DUST, CO AND CH IN THE FRG
BY SOURCES, 1966-1982

		1966	1970	1974	1978	1982
SO ₂						
	% Million t/a	3.2	3.6	3.6	3.4	3.0
1)	power plants	41.3	45.9	51.3	55.1	62.1
2)	industry	35.7	32.3	30.0	27.8	25.2
3)	domestic heating*	19.9	18.6	15.3	13.4	9.3
4)	traffic	3.1	3.2	3.4	3.7	3.4
NO _x as NO ₂						
	% Million t/a	2.0	2.4	2.7	3.1	3.1
1)	power plants	23.6	26.5	30.0	27.8	27.7
2)	industry	30.6	25.5	21.0	16.7	14.0
3)	domestic heating*	5.8	6.0	5.0	4.5	3.7
4)	traffic	40.0	42.0	44.0	51.0	54.6
Dust						
	% Million t/a	1.8	1.3	0.97	0.75	0.7
1)	power plants	25.2	21.8	19.6	22.7	21.7
2)	industry	58.5	57.8	60.8	61.4	59.7
3)	domestic heating*	13.7	15.8	13.4	8.0	9.2
4)	traffic	2.6	4.5	6.2	7.9	9.4
CO						
	% Million t/a	12.5	13.0	11.2	9.1	8.2
1)	power plants	0.2	0.2	0.3	0.3	0.4
2)	industry	13.8	13.7	16.7	14.9	13.6
3)	domestic heating*	52.0	41.7	27.8	18.8	21.0
4)	traffic	34.0	44.4	55.2	66.0	65.0
CH **						
	% Million t/a	1.4	1.7	1.8	1.8	1.6
1)	power plants	0.5	0.5	0.5	0.5	0.6
2)	industry	25.0	26.5	27.0	27.0	28.0
3)	domestic heating*	46.0	42.0	40.0	35.5	32.4
4)	traffic	28.5	31.0	32.5	37.0	39.0

* and other small sources

** CH = organic compounds

Source: Umweltbundesamt 1984

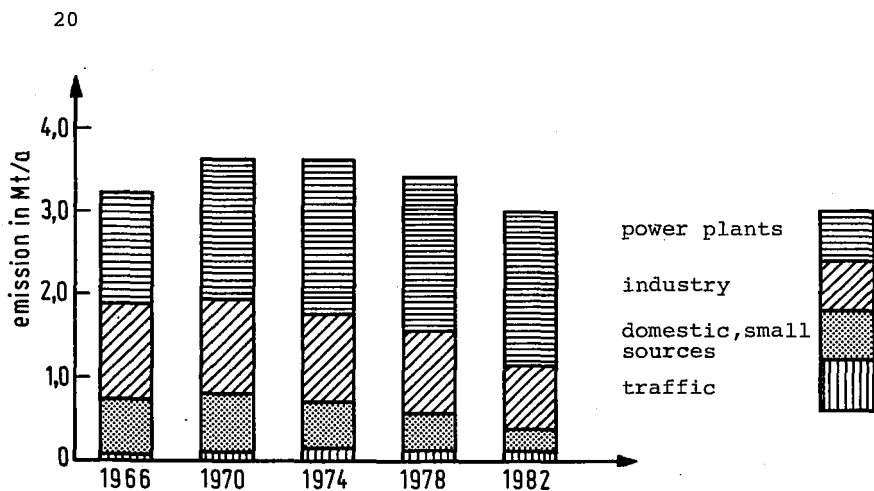


Figure 5. Total emissions of sulphur dioxide, 1966-1982 (source: 3. Immissionsschutzbericht der Bundesregierung 1984).

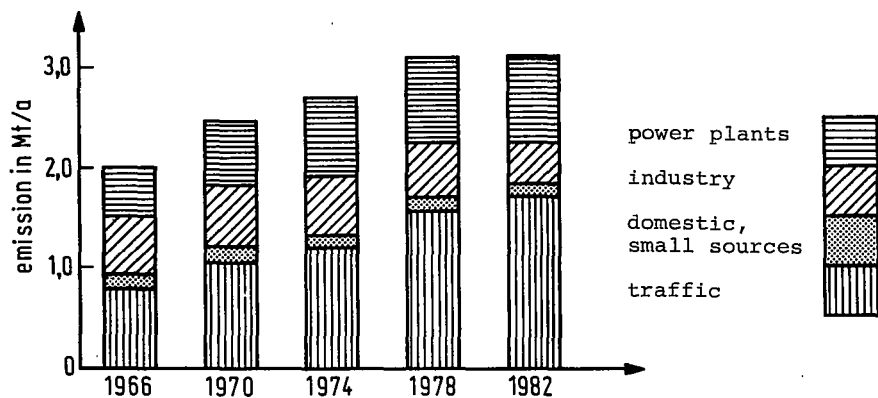


Figure 6. Total emissions of dust, 1966-1982 (source: 3. Immissionsschutzbericht der Bundesregierung 1984).

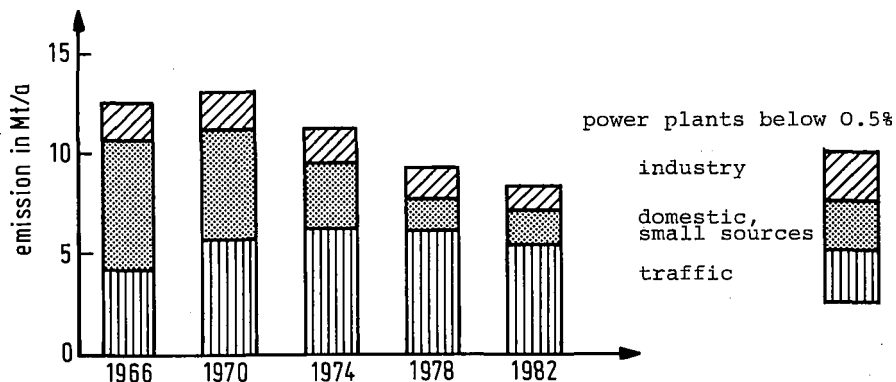


Figure 7. Total emissions of carbon monoxide, 1966-1982 (source: 3. Immissionsschutzbericht der Bundesregierung 1984).

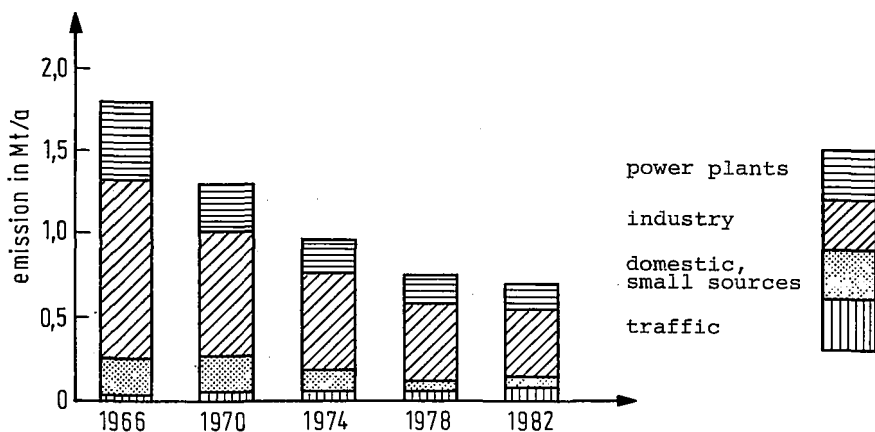


Figure 8. Total emissions of nitrogen oxides, 1966-1982, calculated as NO_2 (source: 3. Immissionsschutzbericht der Bundesregierung 1984).

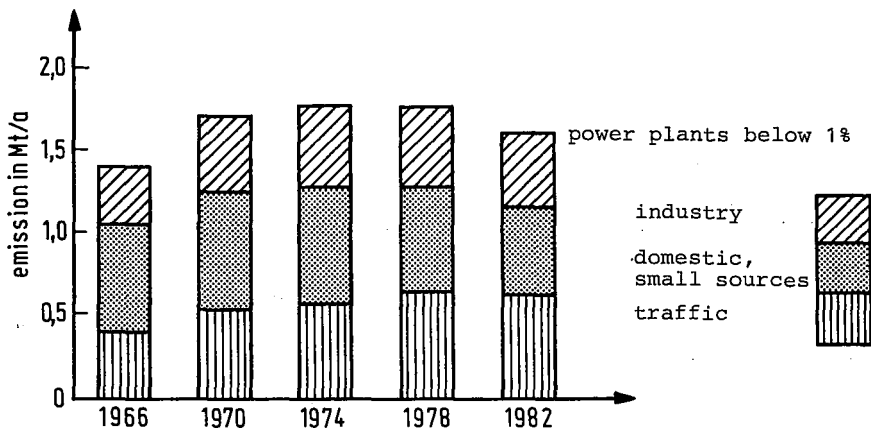


Figure 9. Total emissions of organic compounds (CH), 1966-1982 (source: 3. Immissionsschutzbericht der Bundesregierung 1984).

health is not only, or completely, a result of their emission amount. In most cases, it is also a function of geographical conditions and the height of the emission outlet. Although, for example, conventional power plants are the main contributors to SO_2 emissions, their contribution to air pollution ("immission effect") in residential agglomerations is less than from domestic heating furnaces due to the tall chimneys in power plants. On the other hand, power plants and industry, because of their tall chimneys, are major contributors to long-range transport of air pollutants and, therefore, primarily responsible for the problems indicated by the term "acid rain". Traffic is not only a major source of air pollution in cities, but also in less densely populated and rural areas, due to the dense road network in the FRG. Finally, it is to be mentioned that there is a large inter-regional variety in emitter structure (i.e., the relative contribution of groups of emission sources to total emissions) and as a result of that, a corresponding inter-regional variety in the relative contribution to air pollution by different emission sources. Thus, air pollution control legislation should be flexible enough to

provide instruments and provisions suited to these different conditions.

3. Ambient Air Quality (Immission)

3.1 Monitoring network

There are two monitoring networks in the FRG for monitoring ambient air quality. The first, more comprehensive, one is run by the state authorities, the second, smaller, one is run by the Federal Environment Agency (Umweltbundesamt).

The Federal Environment Agency, which reports to the Federal Minister of the Interior, is responsible for analysing the causes of environmental damage and assessing long-range transboundary air pollution, particularly the deposition of air pollutants. The agency operates a measuring network of 15 stations throughout the FRG, and there are plans to extend it, to form a grid of 100 x 100 kilometre sections. In the final state of development, the agency will operate 25 monitoring stations. The substances presently measured by the agency's monitoring stations and sample-taking places are SO₂, NO_x, CO, O₃, suspended particulate matter (including Pb and Cd in SPM), depositions (including dust, PCB, CD, pH, anions) and meteorological parameters. One of the main objectives of the agency's monitoring network is to provide information about the so-called background pollution, i.e., representative figures on the development of ambient air pollution in rural areas. The following map (fig. 10) shows the allocation of the monitoring stations.

Monitoring of ambient air quality in general is the responsibility of the federal states. The Federal Immission Control Act (FICA), as well as ordinances and decrees by the federal government, establish basic requirements for the size and density of monitoring networks, for pollutants to be measured, for measurement equipment and for how the data are to be analysed.

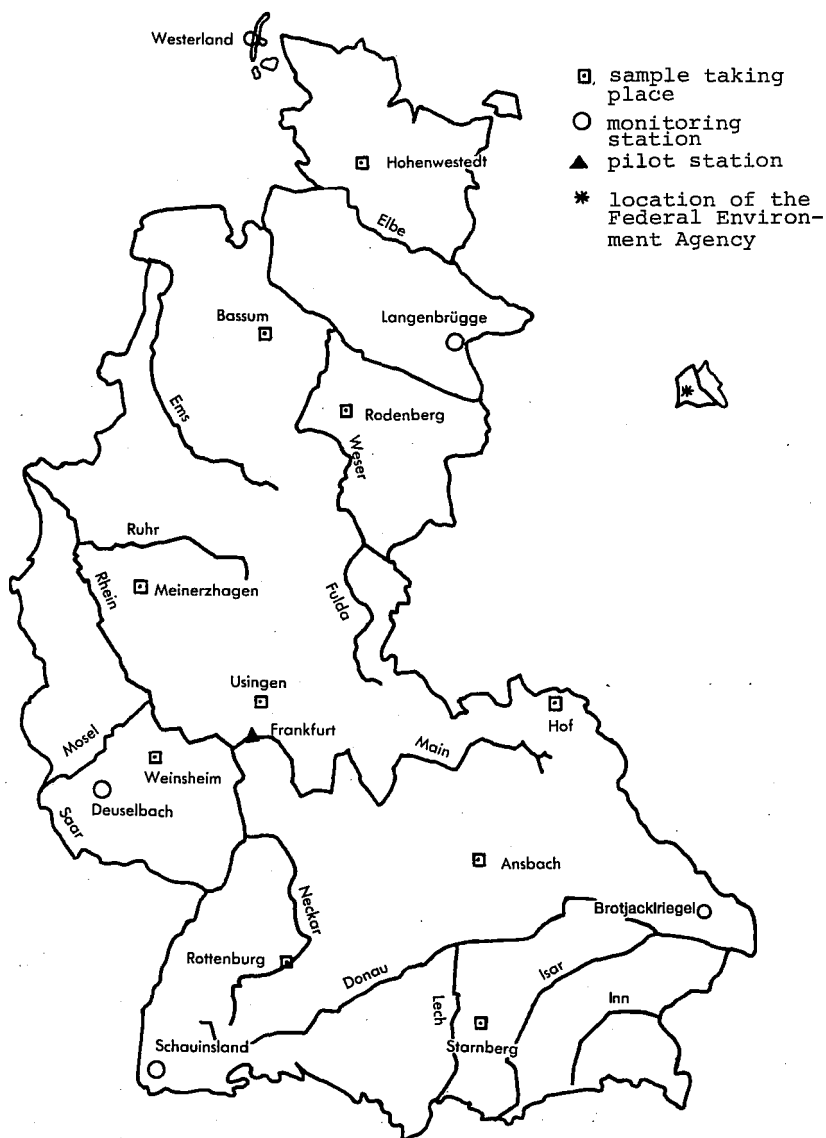


Figure 10. Monitoring network (background pollution) of the Federal Environment Agency (source: Umweltbundesamt 1984).

According to FICA, the states have to establish a monitoring network in designated (heavily polluted) areas. In these areas, as a rule, the following pollutants are to be monitored continuously: SO₂, NO_x, CO, SPM, CH, ozone. In general, the states operate networks with sections (grids) ranging from roughly 4 x 4 km to 8 x 8 km. The number and density of monitoring stations vary from state to state, also the substances measured show a high variety. In addition to the requirements of FICA for heavily polluted areas, some states operate monitoring stations in areas which are not designated as heavily polluted or have established additional monitoring stations in designated areas. In total, the states have established monitoring networks with more than 200 stationary and mobile measurement stations, which continuously monitor the concentrations of major air pollutants in ambient air. Additionally, they operate monitoring stations for taking samples in longer time periods (Stichprobenmessungen). Table 2 provides an overview of the monitoring stations operated by public authorities.

3.2 Reporting on monitoring results

The practise of reporting on monitoring results varies from state to state. In general, there are monthly and annual reports available to the public. Data are usually given for short-term and long-term concentrations. Some states have introduced, for certain areas, a continuously working information system by providing daily concentration values to the public media. A national overview on the development of ambient air quality is provided by reports of the Federal Environment Agency and the so-called "immission control reports" of the federal government as required by FICA. However, both reports provide data in a highly aggregated way and with a considerable time lag. Thus, the data provided by the latest available comprehensive report by the Federal Environment Agency (Daten zur Umwelt), published in 1985, ends with figures for 1982. As a result of severe criticism on the insufficient official environmental reporting in the

TABLE 2
 MONITORING STATIONS IN THE FRG AND PARAMETERS MEASURED
 (AS OF DECEMBER 1983)

Fed. State Regions	Parameters/Substances																Responsible authority		
	SO ₂	NO ₂	NO	CO	CH ₄	O ₃	H ₂ S	SPM dust	Pb	Cd	Zn	BaP	Particles dust	Pb	Cd	pH		Anion	Met
Baden-Württemberg	24	21	13			10		21					88		14	15		15	state
Stuttgart	6	3	4			3		4					62					3	2 Stationen
Mannheim	3	3	3			2		3					14		14			1	Stadt Stuttgart
Karlsruhe	3	3	3			2		2					12					2	
Einzelstationen	12	12	3			3		12											
Bayern	63	19	36	13	20	7	7	37					33	25	25	25	25	29	state
Aschaffenburg	3	1	1	1		1		1					2	1	1	1	1	1	
Augsburg	2	1	2	1	1	1		1					1	1	1	1	1	1	
Burghausen	2	1	1	1	1	1		1					1	1	1	1	1	2	
Ingoistadt-Kelheim	13	1	3	2	3		4	2					3	2	2	2	2	3	
München	10	7	10		6	2		5					10	10	10	10	2	2	
Nürnberg-Erlangen	11	5	3	3	2	1		7					4	4	4	4	2	2	
Regensburg	2	1	1	1	1			2					1	1	1	1	1	1	
Würzburg	3	1	2	1	1	1		2					2	1	1	1	1	1	
Einzelstationen	17	2	11	5	5	2		16					9	5	5	5	5	16	
Berlin (West)	34	2	12					10					252			2	2		state
Bremen	31	1	10					9					250						Bundesgesundheitsamt
	3	1	2					1					2		2	2			

Hamburg	7	7	3	3	3	7	7	7	7	7	state
Hessen	20	18	18	8	4	37	28	28	557		state
Untermain	8	7	7	4	2	20	15	15	378		
Rhein-Main	4	3	3	2	1	3	2	2	58		
Kassel	3	3	3	1	1	4	3	3	80		
Wetzlar	1	1	1			3	2	2	41		
Einzelstationen	4	4	4	1		7	6	6			
Niedersachsen	25	25	6	25	3	25	8	8	86	86	state
Hannover	6	6	1	6	2	6					6
Oker-Harlingerode	5	5	1	5	1	5	5	5	52	52	5
Braunschweig	5	5	1	5	1	5					5
Nordenham	3	3	1	3		3	3	3	34	34	3
Peine	3	3	1	3		3					3
Emden	3	3	1	3		3					3
Nordrhein-Westf.	47	43	28	4	14	122	45	45	3166	1567	state
									(1)	(1)	(1)(2)
									2626		12
Ruhrgebiet-West	11	10	6	2		32	21	21	624	624	3
Ruhrgebiet-Mitte	11	10	8	2		28	17	17	729	729	
Ruhrgebiet-Ost	6	5	5	1		23	17	17	569	569	
Rheinschiene-Mitte	4	4	3	1		14	10	10	214	214	2
Rheinschiene-Süd	7	8	5	3		23	15	15	490	490	3
Einzelstationen/ -gebiete	6	4	1	4	3						4
	2	2		2					540	(4)	
Rheinland-Pfalz	6	6	12	6	2	6					2
Mainz-Budenheim	3	3	6	3	1	3					1
Ludwigshafen- Frankenthal	3	3	6	3	1	3					1

(CONTINUED OVERLEAF)

(TABLE 2 CONTINUED)	Parameters/Substances															Responsible authority			
	SO ₂	NO	CO	CH	CH ₄	O ₃	H ₂ S	SPM dust	Pb	Cd	Zn	BaP	Particles dust	Pb	Cd		pH	Anion	Met
Saarland	11	3	3	3	3	2		7	2				368	77				3	state
Saarbrücken Dill. Neunkirchen Habkirchen/Bliesg. Einzelstationen	9	3	3	3	3	2		6	1			223	58	77	77			3	
Schleswig-Holstein	7	7			7	7		7										7	state
Brunsbüttel Einzelstationen	2	2			2	2		2										2	
Bundesweite Meßnetze	5	5			5	5		5										5	
UBA-Meßnetz	17	8			2			18	8	8			5	5	5	5	5	6	federal government
Meßstationen Probenahmestellen Kl. Feldberg/Is. Frankfurt/Stadt	5	5						5	5	5			5	5	5	5	5	5	
KfA-Meßnetz	2	3	3		2			2	2	2			12	12	12	12		1	KfA Jülich
total:	261	159	134	17	72	54	7	297	91	89	45	35	4557	1772	1695	44	(2)	106	

(1) Number of 1 x 1 km areas (2) monitoring period: every 5 years (3) only NO (4) in 5 areas

Met = meteorological parameters

Source: Umweltbundesamt 1984

FRG, activities have recently been started by the responsible authorities to improve the situation.

3.3 Monitoring results

Based on the available information on ambient air quality development during the last decade, the following general conclusions can be drawn for major pollutants:

- (1) Sulphur dioxide: SO₂ concentrations dropped considerably during the 1960s in many polluted areas. However, this trend levelled off during the 1970s. At present, the majority of monitoring stations show a divergent picture. Yet, despite these differences, there are quite clear indications for a long-term stabilisation of concentrations in a range of 70 - 140 mg/m³. This levelling off of improvement rates (stagnation) in the late 1970s and the early 1980s is especially prominent in densely populated and highly industrialised regions. In contrast, in some rural areas, a slight increase in pollution was monitored. However, in general, the long-term ambient air quality standard (140 mg/m³) is now complied with by all monitoring stations, whereas the short-term standard (400 mg/m³) is still exceeded at some monitoring stations in urban areas. Especially during the winter months very high peak concentrations are reported not only from stations in metropolitan areas, but also in rather rural areas. Scientists and the public have criticised repeatedly that peak concentrations (not only for SO₂ but also for other pollutants) are not sufficiently considered in air pollution control strategies.
- (2) Nitrogen oxides: NO₂ concentrations show an overall increase. The highest concentration values are reported from stations close to roads. The annual concentration levels lie in a range of about 50 - 100 mg/m³ in agglomerations and in a range of 10 - 20 mg/m³ in rural areas.
- (3) Carbon monoxide: no improvement in urban areas; especially monitoring stations at roadsides report high concentration levels.

- (4) Particulates: the improvement rate in dust deposition levelled off in the late 1970s. Since then, the situation remained nearly the same (stagnation) in urban agglomeration areas. In some industrial areas, the standards are still exceeded. For suspended particulate matter (SPM), the trend is also ambivalent: SPM concentrations showed a slight decrease in heavily polluted areas, while in "normal" areas the situation remained nearly the same.
- (5) Other pollutants: the standards for some heavy metals (lead, cadmium) are still exceeded in some industrial areas. However, a slight improving trend is reported for cadmium and, to a greater extent, for lead due to the "Lead in Petrol Reduction Act". For organic compounds, which constitute a class of pollutants exhibiting intrinsic health and ecological effects, the situation in general remained bad. The federal government admitted that there is a strong need to extend and improve monitoring of these compounds. Photochemical oxidants such as ozone, hydrogen peroxide, etc., have undergone systematic investigation only recently. Available data indicate that high concentrations arise in some regions in the summer. It is assumed that concentrations of ozone will show an upward tendency because of increasing NO_x emissions.

3.4 Special features of air pollution problems

Available data on emissions and concentration levels indicate that until the beginning of the 1980s only rare improvements for both traditional and trace pollutants have been achieved. With the exception of dust, a large part of the improvements in urban agglomerations and industrial areas have been achieved by the strategy of "problem dislocation" (tall chimneys). Problem dislocation (or problem shifting) usually occurs when insufficient consideration is given to the ecological context and the long-term effects of pollution, especially when the prevailing environmental political strategy is one of peripheral and selective intervention.

Intervention is selective when the environmental political focus is only on one part of the ecological context in which damage has become manifest and when remedial activities are limited to that part, i.e., dealing incrementally with air, water, soil, etc. pollution with medium-specific policies and without a systematic coordination of these policies. A peripheral intervention is a policy which does not tackle the cause of a pollution problem in an attempt to eventually overcome it but instead simply "manages" (mitigates) pollutants or controls the last link in a chain of events. In the field of air pollution control, for example, this could be the abatement of harmful emissions by dilution (e.g., tall smokestack dispersion policies) or aggregation (e.g., end-of-pipe technologies such as desulphurisation plants) instead of pursuing energy saving measures, changes to non-pollution energy sources or introducing structural changes which would be ecologically sound.

A strategy of selective and peripheral interventions may achieve short to medium-term improvements, but progress will soon slow down and new problems emerge. There are at least two reasons for this development: first, the ongoing accumulation of residual pollutants caused by the structurally unaltered sources of problem generation is not prevented, especially when economic growth offsets the positive effects of abatement measures, which rarely achieve 100% success, and secondly, pollution problems are constantly being shifted from one environmental medium to another.

There are various forms of such an environment-related "problem dislocation" which must be given special consideration in evaluation studies. According to my experience in evaluation research, "problem dislocation" can be classified in the following way:

- o Medial problem dislocation: Environmental problems are shifted from one medium to another, e.g., from air to water or soil. Dust collectors, for example, reduce air pollution at the expense of higher water or soil pollution when dusts are recklessly disposed of.

- o Spatial problem dislocation: One region is "cleaned up" at the expense of others, e.g., air quality in urban agglomerations is improved through long-range distribution of pollutants.
- o Temporal problem dislocation: Environmental problems are spread over a lengthy period of time, e.g., the concentrations of pollutants in the ambient air are being diluted thus avoiding immediate and acute health injuries. This may create a short-term mitigation of critical problem situations, yet, the continuous and long-term exposure to pollutants induces chronic diseases (or impairs well-being) which become noticeable relatively late and are then difficult to trace back to their actual causes.
- o Problem dislocation caused by substitution measures: Industrial processes, raw materials, fuels, etc. are substituted by others (sometimes in response to environmental policy decisions) which may pollute the environment to the same or even to a greater extent, e.g., switching from fossil fuels to nuclear power or substituting phosphates in detergents, which contribute to the eutrophication of water bodies, for the chemical substance NTA, which may wash out heavy metals from river and lake sediments.

In the area of mobile sources, with the exception of lead, no improvements have been achieved so far. Furthermore, relatively weak control of the drastically growing number of chemicals have generated or increased the problems with numerous "new pollutants". Taking all this into consideration, the special features of air pollution problems in the FRG are made up of

- o emissions of major air pollutants by power plants and other large combustion plants, especially contributing to the long-range transport of pollutants;
- o emissions by mobile sources, especially nitrogen oxides and hydrocarbons, contributing in a massive way to air pollution in cities, to the formation of photochemical oxidants and, also, to long-range transport of pollutants;

- o increasing concern, hints and verifications that industry and especially waste incineration plants emit a large variety of harmful or toxic substances, at present not sufficiently controlled or even monitored.

Given these features of air pollution problems, the following general characterisation can be made: most of the emissions of major air pollutants are a result of combustion processes in stationary and mobile sources, whereas the emissions of new, more complex, pollutants are mainly a result of not systematically controlled inputs (raw materials) in industrial processes or the final treatment of industrial outputs after use (waste incineration). This unfavourable situation is primarily the result of belated political intervention in the planning and development of pollution-generating projects, and of selective and peripheral intervention in already existing problem areas. Basically, air pollution control in the FRG is only reactive (with the emphasis on restorative aspects after environmental problems have occurred). Moreover, reactive policies usually only set in after the environment and/or human health have been more or less massively harmed. Approaches based on the maxim "anticipate and prevent" have as yet not become a part of air pollution control policy in the FRG. It should, however, be mentioned that reactive policy measures have become more effective since about 1983.

Finally, in a densely populated and highly industrialised country, such as the FRG, emissions of air pollutants contribute significantly to soil pollution, especially by toxic and bio-accumulating substances. Having ignored the relationship between emissions of air pollutants and soil pollution for a long time, the federal government recently issued a comprehensive proposal for a soil protection programme (Bodenschutzkonzept) and announced future legislation on this subject. However, as of June 1986, no effective implementation activities have been started.

4. Future Trends of Air Pollution Problems

Due to recently passed laws and regulations to cope with air pollution from stationary and mobile sources, as well as special action programmes of state authorities, the following trends in emissions and ambient air quality can be expected for the decade from 1985 to 1995:

4.1 Trends in emissions from stationary sources

Recent amendments to FICA and the Technical Instruction for Maintaining Air Purity (TI Air), enacted in October 1985 and early 1986 respectively, provide stricter and improved instruments and requirements for cleaning up existing sources, or enforcing stricter emission limits for new sources. The amendments also create more incentives, and by this greater flexibility, for emitters in introducing appropriate abatement measures. The TI Air amendment of 1985, officially deemed the core of the second extrapolation of the action programme "Save the Forest", establishes, inter alia, new requirements for nearly all industrial emitting sources, especially for smaller furnaces not regulated under the ordinance for large combustion plants. It also establishes stricter emission limits, especially for carcinogenous substances and special harmful heavy metals; for example, benzol (old standard: 20 mg/m^3 , new standard: 5 mg/m^3), arsenic (old standard: 20 mg/m^3 , new standard: 1 mg/m^3), and cadmium (old standard: 20 mg/m^3 , new standard: 0.2 mg/m^3). In addition, it provides clearer and more systematic requirements for improving (cleaning up) existing (old) sources by setting time periods for implementation: the new provisions have to be implemented, as a rule, within five years, or, in special cases, within three or ten years.

Official estimations of future emission trends based on the prospective effects of these new requirements are

- o for dust: a reduction of dust emissions in the industrial sector (excluding power plants) from 400,000 tonnes per

year (1982) to 160,000 tonnes per year (reduction of 40%). Together with new requirements established by other legislation, primarily by the ordinance for large combustion plants, total dust emissions will be reduced, in the long term from 700,000 tonnes per year (1982) to 450,000 t/yr.

- o for heavy metals: a reduction of about 40% is expected;
- o for sulphur dioxide: a reduction from 540,000 t/yr. (1982) by nearly one-third. All measures combined (including those under the ordinance for large combustion plants) are estimated to reduce the total amount of SO₂ emissions from 3 million t/yr. (1982) by 1.9 million t/yr. to about 1.1 million t/yr. in the long term;
- o for nitrogen oxides: the total amount of 270,000 t/yr. (1982) emitted by facilities regulated under TI Air is expected to drop by 100,000 t/yr. to 170,000 t/yr. All new requirements combined are expected to lead to a reduction of total emissions (stationary sources) from 1.3 million t/yr. (1982) to 0.8 million t/yr. in the long term.

According to a recently published study by the Federal Environment Agency on the long-term effects of the Ordinance for large combustion plants, the following estimates can be made on the basis of the legally required declarations of operators of large combustion plants:

- o sulphur dioxide: the annual SO₂ emissions from large combustion plants will decrease from more than 2 million t/yr. (1982) to 0.8 million t/yr. by 1988 (a reduction of 1.2 million tonnes). By 1993 the total amount will have dropped to 0.5 million t/yr., i.e., a reduction rate of 75% from 1982 to 1993;
- o nitrogen oxides: according to the estimates, the total amount of NO_x emissions from large combustion plants will decrease from 1 million t/yr., at present, to 0.3 million t/yr. in the early 1990s (a reduction rate of about 70%).

Based on these official estimates, relatively large reductions of emissions from nearly all facilities can be expected by the mid 1990s. Critics declare that these are optimistic estimates, based on the expectation of a full and strict enforcement of the new regulations by state authorities. They also point critically to the fact that most of the expected effects in emission reduction will take place after a rather lengthy time period, whereas faster measures are needed to save the forests. This criticism is directed especially at recently (1985) enacted requirements for exhaust control of automobiles and the decision of the federal government not to introduce a general motorway speed limit and not to reduce the current speed limit on state highways from 100 km/h to 80 km/h.

4.2 Mobile sources

In 1985, the EEC member countries agreed on new exhaust standards for new automobiles, which are less strict than the standards initially proposed by the German federal government. Due to the weak requirements of the EEC directive, estimates based on prognoses on the future trends in traffic increase came to the conclusion that until 1993 NO_x emissions by automobiles will increase. Thus, a remarkable reduction of NO_x emissions will take place only if a general speed limit of 100 km/h on motorways (Autobahnen) and 80 km/h for state highways (Bundesstrassen) is set. Taking into account these estimates, the NO_x concentrations in ambient air will remain nearly stable in general areas until about the early 1990s, whereas for urban areas an increase is to be expected.

5. Air Pollution Damage and Its Costs

Although the exact nature and extent of damage through all air pollutants evidently require further study, it is not disputed that previous and current air pollution levels have caused, in some cases massive, damage to human health, materials,

plant life, rivers and lakes, and soil. In the FRG, only a few comprehensive and systematic empirical studies on damages from air pollution have been made so far. They mainly focussed on damage to forests and materials, and less on health effects. Recently, growing concern with air pollution effects on rivers, lakes and soil has led to a promotion of studies in these problem areas. Especially for investigations into the health effects of air pollution, there is a strong demand by both the public and scientists alike to increase toxicological and epidemiological research. What has been said about the state of damage research also applies for research on the benefits of air pollution control, although the general statement is not disputed that even in economic terms expenditures on pollution abatement are, in the long term, more favourable than to pay for damage cures.

5.1 Public health

Compared to other industrialised countries which have been challenged by high air pollution loads surprisingly few studies have been devoted to health effects of air pollution in the FRG. This is not only indicated by the weak position of epidemiological research in public and private institutions, but also by figures on the development of expenditures by the federal government for R&D in the area of air pollution: in the period 1976 - 1980, the federal and state governments spent a total sum of 816 million DM, of which only 28 million DM was used for studies on the effects of air pollution in general, and only 8 million DM thereof was allotted for studies on effects on human beings. Recently, some state governments have increased their funding, especially for epidemiological studies, due to the growing public concern about harmful effects of air pollution to human health and well-being.

Despite the lack of comprehensive and commonly accepted data, there is evidence for significant adverse health effects resulting from both high and low concentrations of several air

pollutants. As early as 1962 an investigation revealed that a smog catastrophe in the Ruhr River Valley in December 1962 led to an increase in the mortality rate (156 more persons died than in the same period of the previous year). Several other studies and information show that mortality and human health, especially of the young and the elderly, are affected in smog episodes. A recent study, performed in West Berlin, identified that the mortality rate of the elderly is about 15% higher after winter days with a high air pollution load (parameter: SO_2) than in times with low air pollution. In heavily polluted areas (e.g., Duisburg), more than twice as many people suffer from bronchial diseases than those in rural areas. It is generally acknowledged that in areas with a high air pollution load there is a significantly higher rate of respiratory diseases (especially among the so-called risk groups: children, elderly persons). According to an official statement of the Federal Ministry of the Interior in 1983, for the past decade, not only have diseases of the respiratory tract increased in areas with high air pollution, but also susceptibility to infections. There is also growing concern by pediatricians and parents about the increase of allergies among children as well as pseudo-croup and sudden infant death syndrome, which they assume to be, at least partially, caused by air pollution. Despite contradictory results of scientific studies and statements of public officials and politicians responsible for environmental protection, there has been a growing belief throughout the general public, since 1983, that air pollution contributes to illnesses in a much stronger way than was previously believed. At present, medical doctors considering the effects of air pollution in their research and practice are still in the minority. However, there are clear indications of growing interest in this issue.

Not only is concern about detrimental health effects of traditional (major) air pollutants growing, but also on the effects of a large variety of toxic substances and gases, due to the increasing production and emission of new and

complex chemicals. There are hypotheses that they have contributed to the increase of cancer and, in certain cases, to deformities (dioxin). Furthermore, area studies conducted in the vicinity of chemical industry, glass and zinc production plants revealed high heavy metal concentrations in the blood of children. Reports of the Federal Environment Agency provided evidence that asbestos, lead, cadmium, etc. have led to harmful health effects in a significant way.

Finally, it should be noted that the lack of comprehensive and reliable data on health effects of air pollution, as well as the small amount of research in this area, is in sharp contrast to the degree of public concern and interest in information about this subjects.

5.2 Forests and plants

The recent forest damage in Europe have been recorded particularly thoroughly in the FRG. After an alarming increase of damage in areas remote from industry, an estimation of damage was carried out in the autumn of 1982, identifying 8% of the forested area as being injured. Repeated assessments with unified criteria of evaluation during 1983 showed that 34% of the total forested area was injured, centering on the Bavarian forest, Fichtelgebirge, Frankenstein, Harz and the Black Forest. Damages have also been observed in the Alps and other areas which were not afflicted before. The fourth assessment in 1985 showed that the total proportion of trees affected rose from 34% in 1983 to 50% in 1984 and to 52% in 1985 (see table 3).

The results of the 1984, and especially of the 1985 survey show that 3.7 million hectares of the wooded area are damaged. Compared to the previous year (1983), when the damaged area was 2.5 million hectares (1 hectare = approx. 2.47 acres), this is a considerable increase, even when taking improved surveying methods into account.

TABLE 3
SURVEY OF FOREST DAMAGE 1983, 1984, AND, PARTIALLY, 1985

Species of tree	Degree 0 no signs of damage		Degree 1 slightly damaged		Degree 2 moderate damage		Degrees 3 and 4 very sick and dead		Total degrees 1+2+3+4	
	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984
	as % of area covered by species									
Spruce	59	49	30	31	10	19	1.1	1.6	41	51
Pine	56	41	32	38	10	20	1.4	1.3	44	59
Fir	25	13	27	29	41	45	7.3	12.8	75	87
Beech	74	50	22	39	4	11	0.4	0.8	26	50
Oak	85	57	13	35	2	9	0.2	0.4	15	43
Other Species	83	69	9	24	8	7	0.4	1.0	17	31
Total (1983 + 1984)	66	50	25	33	9	16	1.0	1.5	34	50
Total 1985	48.1		32.7		17		2.2		51.9	

Note: Figures for 1983 and 1984 are rounded.

Source: Federal Ministry for Agriculture, Forestry and Food; and Europe Environment No 227/ March 1985.

TABLE 4

TOTAL DEGREE OF FOREST DAMAGE BY STATES, 1982 TO 1985 AS % OF FOREST AREAS

State \ Year	1982	1983	1984	1985	Changes '84-'85
Schleswig-Holstein	18	12	27.4	35.5	7.1
Lower Saxony	13	17	36.2	36.0	- 0.3
North Rhine-Westphalia	9	35	41.9	36.8	- 5.1
Hesse	5	14	42.4	46.6	4.2
Rhineland-Palatinate	1	23	42.0	46.3	4.3
Baden-Württemberg	10	49	66.2	66.1	- 0.1
Bavaria	7	46	57.0	60.6	3.6
Saarland	4	11	31.1	37.9	6.8
Bremen	-	-	-	52.3	-
Hamburg	-	-	56.2	77.3	21.1
Berlin (West)	-	-	52.5	76.2	23.7

Note: According to methodological deficiencies, the figures for 1982 are not quite reliable.

Source: According to statements of the Federal Ministry for Agriculture, Forestry and Food.

The 1984 survey also showed that deciduous trees suffered heavy damage. During the second and third survey, there was a more rapid increase in damage among beeches and oaks than among conifers, so that the differences in the degree of damage among the various types of trees have narrowed. The recently published (January 1986) results of the 1985 survey show that about 52% (approx. 3.8 million hectares) of the total forested area is injured. 19% of the forested area show moderate to heavy damage (damage classifications 2 to 4), an increase of 2% as compared to 1984 (cf. table 4).

Despite the present lack of final scientific evidence, most experts believe that air pollutants play a crucial part in causing and determining the extent of damage, either alone

or in combination with other air pollutants and factors. In March 1983, the "Council of Environmental Advisors" issued a special report entitled "Forest Damage and Air Pollution" (Waldschäden und Luftverunreinigungen). They acknowledged that all serious attempts to explain the problems came to the result that air pollutants play a decisive part in causing damage to forests and among them sulphur dioxide and nitrogen oxides, and their transformation products, are the most important ones. Initially, acidic precipitation (acid rain) was seen as the main cause of damage. Recent opinion, however, has tended towards the idea that photochemical oxidants derived from nitrogen oxides under the impact of sunlight, and particularly ozone, also play a significant part. Therefore, present knowledge seems to confirm that, without air pollutants, the problem of dying forests would not occur.

The problem of massive damage caused to forests by air pollution is not a new phenomenon of the 1980s. Since the early 1970s, and with a considerable increase in 1976, there have been reports on serious damage of a new form caused to firs in the south of the FRG. About the same time, damage was reported on spruce trees. Damage to forests occurred initially among older populations of trees in higher mountainous areas. However, later on, younger trees and forests in lower regions were increasingly affected.

According to estimates of the "Union of German Forest Owners' Associations", the financial loss owing to damage to forests amounts to nearly 1 billion DM per year. New estimates, on the basis of the third survey, put the annual damage at 1.4 billion DM. There are estimations that the economic loss will amount to billions of DM per year if the damage rate continues to increase.

It is not only the economic loss to forest owners which makes the problem of dying forests a national issue, and a challenge for air pollution control policy, but also other functions the forest provides. It serves, inter alia, to protect

property against pollution, as well as to protect soil and the regional climate. Should these functions be heavily impaired, then a general deterioration of ambient air quality, drinking water quality, the climate, the living conditions of animals, etc., will deteriorate. Furthermore, soil erosion, landslides, rockslides, avalanches will increase. Finally, without having figured out all the problems and damages potentially resulting from dying forests, the recreational and aesthetic functions of forests, as well as their economic functions for many persons who derive their livelihood from tourism, will be (and partly are already) impaired.

The costs to society caused by damage to forests include also costs for avoidance and abatement. So far, a great deal has been spent on fertilisation, liming, and other remedial measures. In 1984, for example, the federal and state governments appropriated about 33 million DM to subsidise fertilisation or replanting of damaged forests, etc. The related budget for R&D was also increased considerably. Finally, it is to be pointed out that figures and estimates on damage costs concentrate on those effects that are physically measurable and which can be transformed into economic terms. In addition to such effects, and this is especially true for the immaterial value that forests are given by Germans in general, there are those effects which cannot be physically measured or expressed in economic terms but nevertheless generate massive mobilisation of the general public and challenges to politicians and industrial emitters hitherto not experienced in the FRG.

Damage to plants has been repeatedly reported, in many cases as a result of specific pollutants, for example, cadmium, lead, and fluor. The so-called "red list" of endangered plants, which was updated in 1984, showed an increasing threat to the flora. Sufficient data on the magnitude of effects due to exposure to air pollution are not available. But damage to plants within and without forest ecosystems has been increasingly reported. Thus, the federal

government admitted in 1984 that the assumption must be taken seriously that forest damage is only one sign for a greater threat to other vegetation and, thus, to the environment as a whole. Environmental protection groups have also included human beings into this perspective, as expressed in one of their most popular slogans: "First dies the forest, then human beings" (erst stirbt der Wald, dann der Mensch).

5.3 Rivers, lakes and soil

Recent investigations have shown that the unpolluted upper parts of rivers and streams with low buffering capacity (lime content) have been significantly acidified. High concentrations of sulphur and aluminium, by far exceeding the standard for protecting fish, have also been recorded. Preliminary reports on lakes have shown that acidification mainly appears in areas where forests are also damaged. Acidification has an important side-effect: it contributes to the release of heavy metals which then can damage the quality of ground water. Available data do not allow an estimate of economic losses due to water pollution by air pollutants. In 1984, the federal government stated in a report that acidification of lakes and rivers is caused by sulphur and nitrogen oxides primarily resulting from the combustion of fossil fuels. Air pollution also introduces other pollutants into the water, such as heavy metals, phosphates and halogen compounds.

Most air pollutants, once emitted into the air, will deposit on the soil. Although the soil is for many air pollutants a "final target" where accumulation of air pollutants can reach critical values, even if the concentrations in the ambient air may be minor, the relationship between air and soil pollution was not investigated or made a political issue until recently. Thus, national data on damage to soil and damage costs are not available. But it is generally acknowledged that air pollution is one of the major causes of soil pollution. Since 1982, the federal government has promoted the development of a comprehensive soil protection concept, which

was approved by the government in 1985. At present, this concept is still on the political agenda. Legislation on this subject is probably not to be expected before 1987. Some groups are critical about the long period of time needed to reach legislation and implementation, but many groups admit that the concept as such is well-established and very ambitious.

5.4 Materials

For many years, damage to materials by atmospheric pollution has been observed. All types of buildings and materials suffer corrosion from pollution. Particularly distressing, however, is the damage caused to architecturally and historically valuable buildings, monuments and medieval stained-glass windows. A well-known case is the Cathedral of Cologne (Kölner Dom), the sandstone of which is seriously decaying. Similar alarming symptoms are found at numerous other famous buildings. As such buildings, monuments or sculptures represent irreplaceable values, the damage costs (cost occurring for renovation, preservation, etc.) show only a small fraction of the total loss. Taking the 5 million DM per year for preservation of the Cathedral of Cologne as a basis, an estimate can be made that material damage to architectural and artistic monuments in FRG amounts to more than 300 million DM. In an OECD study it was calculated that a reduction of sulphur dioxide emission by 37% (involving expenditures of US \$ 516 million) would lead to a reduction of damage in the order of US \$ 320 million for galvanised and coated steel constructions alone.

Although the estimates for damage costs must be considered with care, it seems to be well-established that the damage to human artifacts (buildings, constructions, works of art) by exposure to air pollution result in losses of far more than 3 billion DM per year.

5.5 Economy in general

Research on the effects of air pollution control on the economy concentrated on those effects that are physically measurable and which can be transformed into economic terms. Even on these measurable effects, studies are rather rare, and there is no comprehensive and systematic study on all relevant aspects (inflation, employment, economic growth, technological progress, etc.). Given these limitations, the following general conclusions can be drawn from the available studies:

- o There is clear evidence that air pollution control has had positive effects on economic growth and the GNP. One should, however, bear in mind that the national accounting system also records so-called defensive expenditures (including avoidance and abatement costs) for compensating damage, impairment or deterioration induced by air pollution.
- o There are no figures available on the effects of air pollution on employment. However, the impacts of pollution control programmes (including all areas: soil, chemicals, water, air, noise, etc.) on employment are reported to be positive. According to several studies, cleaning up the environment creates new jobs and/or safeguards existing jobs. From 1971 to 1977, about 215,000 jobs per year were either created or maintained in this sector. There is no evidence that this positive effect has changed since then. In addition, research has shown that pollution control regulations do not only stimulate firms in a significant way to shift new (or old) production capacity out of the FRG to countries with less stringent pollution control regulations. There are only a few examples that permits for new facilities have been rejected or that enterprises have been closed down on grounds of air pollution concerns. However, there have been some delays in issuing permits to potentially large emitters (especially power plants) due to opposition by third parties or environmental action groups.

- o There are no data available indicating a general negative impact of air pollution problems or air pollution legislation on new investments. In contrast, studies have shown that investments have been stimulated by environmental regulations. A recent study reported that the new air pollution legislation of 1983 will increase industrial investments in terms of several billion DM. For example, it is estimated that in the area of power plants, investments of about 20 billion DM will be encouraged until 1990 by air pollution legislation. Some products may become more expensive and electricity rates presumably will increase due to measures required by the ordinance concerning large combustion plants of 1983 and the TI Air of 1983 and 1985. But, as surveys have shown, the overwhelming majority of the population is willing to pay more if this should improve environmental conditions.

When comparing the available data on damage costs from air pollution (especially to buildings, monuments, forests, human health) with the effects of air pollution control legislation on the economy, the net effect is that, at present, air pollution has had a significant, adverse impact on the general economy. Furthermore, a study published by the OECD in 1979 estimates that environmental damage in industrialised countries amounts to about 3 to 5% of the annual GNP. (Note: at the time that study was prepared, damage to forests was not yet known.) According to OECD's estimates, environmental damage in the FRG amounted to 40 - 70 billion DM in 1979. Thus, although estimates on costs and benefits of pollution control legislation as well as damage from air pollution should be taken with care, it seems well-established that actual economic losses are much higher than the costs that would incur from pollution prevention measures.

II A BRIEF HISTORY OF AIR POLLUTION CONTROL POLICY IN THE FEDERAL REPUBLIC OF GERMANY

1. The Development of Programmes and Legislation

Air pollution has been a concern of German governments for a long time. As early as the 19th century, German scientists conducted thorough investigations on the damage caused by smoke pollution. More systematic legislation directed towards air pollution problems caused by industrial establishments started with the "general trade regulation", enacted by the Prussian government in 1845. It established, inter alia, a permit system for designated facilities and empowered the responsible authorities to place conditions on emitting facilities. The basic principles of this law-like regulation later on were transferred to the "trade regulation" of the North German Confederation (Norddeutscher Bund) in 1869. Shortly afterwards, it became valid for the German Reich. A "technical directive for air" was passed in 1895. Both the trade regulation of 1869 and the technical directive of 1895 formed the basis for air pollution control for about 100 years, until 1959 and 1964, respectively. The main objectives and strategies of the trade regulation, in combination with the Civil Code, was to protect human health and property in the neighbourhood of emitting facilities. Pollution abatement measures were primarily implemented by "diluting" emissions and building higher chimneys insofar as gaseous emissions were concerned. With respect to dust, filter techniques were developed quite early.

Because of the limited scope of pollution control regulations, air quality continuously deteriorated. A major concern in the 19th century had been harmful effects to human health and damages to property and forests from dark smoke. With rapid increases in industrialisation, especially after the Second World War, air pollution problems, as well as the range of harmful substances emitted, increased. But it was not until the mid-1950s that serious debates on air pollution control

legislation began. They resulted in amendments to the Trade Regulation Law (Gewerbeordnung) and the Civil Code (Zivilrecht) by a special law enacted on December 12, 1959, which can be considered as the first framework law on air pollution passed by the federal government. It was commonly referred to with its short title as "Clean Air Maintenance Law". In 1964, a "technical instruction for maintaining air purity" was issued by the then responsible Federal Ministry of Health. Compared to the old legislation, the Clean Air Maintenance Law of 1959 provided for some basic improvements, for example, the list of designated facilities requiring a permit was extended, standards for enforcement were made stricter, the so-called neighbours' right was strengthened with regard to damage from air pollution, and the responsible authorities were provided with the administrative instrument of improvement orders. The TI Air of 1964 contained, inter alia, the licensing procedure for industrial facilities requiring a permit, ambient air quality standards for five air pollutants, and the stipulation that all emitting facilities be equipped with the best technical control devices available.

The new federal legislation for air pollution control contained decisive restrictions to an adequate coping with the increasing and more complex air pollution. For example, air pollution from traffic and small facilities was not included and no appropriate means were provided for controlling pollution according to regional needs. North Rhine-Westphalia, as the most polluted state of the FRG, became a forerunner in developing new clean air strategies which later on influenced national legislation considerably. Thus, the government of North Rhine-Westphalia was the first among the federal states to enact an "immission control act" in 1962. It contained, in contrast to the national law, requirements for small and domestic emission sources. It was, again, the government of North Rhine-Westphalia which enacted the first smog-oriented ordinance (1964), built up a comprehensive monitoring system and developed a strategy of "clean air programmes", which were aimed at the reduction of pollution loads in heavily polluted areas.

Compared to previous legislation, laws and regulations were decisively modified in the late 1950s and the 1960s. Nevertheless, the main task of air pollution was still perceived as one to reduce emissions which could harm the health of people living in the vicinity of emitting facilities. Thus, to a great extent, air pollution policy was just one of many (and often minor) aspects to be considered by factory inspectorates. In so far, air pollution control policy, until the end of the 1960s, was more or less an appendix to industrial policy. It was not until 1970 that air pollution control policy was conceptualised and then, in 1974, by legislation established as an autonomous policy area.

The "modern phase" of air pollution control policy in the FRG started with two environmental programmes, especially the comprehensive environmental programme of the federal government of 1971, issued by the then governing social-liberal coalition (Social Democratic Party/Free Democratic Party). This programme covered nearly all environmental areas, and, most importantly, established the basic objectives and principles of environmental policy, especially the precautionary, the polluter pays, and the cooperation principles (for definition of these concepts, see next chapter). Guided by the principles of this environmental programme and by the already enacted state immission control acts, among which that of North Rhine-Westphalia was the most influential one, parliament enacted the Federal Immission Control Act (FICA) in 1974, after the federal government had obtained stronger so-called concurrent legislative power in the area of air pollution in 1972. FICA covers not only air pollution control, but also noise, vibration, and similar phenomena. This law created a completely new legal basis for air pollution control in the FRG. It was, quite rightly, described as one of the most comprehensive and modern laws for the protection of ambient air, especially in conjunction with the new Technical Instruction for Maintaining Air Purity (TI Air), issued as the first general administrative regulation on the basis of FICA. The new TI Air replaced the old TI Air

of 1964 and provided details for implementing FICA. Like its predecessor, the TI Air of 1974 is the major tool for the guidance of air pollution control policy implementation. As early as 1971, against powerful and vehement opposition by industrial pressure groups (especially refineries), the Lead in Petrol Reduction Act was enacted. The law provided for the reduction of the lead content in gasoline-based fuels.

The enactment of FICA in 1974 provided the basis for many subsequent legislative activities. Until the end of the 1970s, a bulk of ordinances, decrees, guidelines, etc., aiming at air pollution control, have been issued (see section III below). Thus, the phase from 1974 - 1983 can be characterised as a mixture of legislative and enforcement activities to implement the basic principles of FICA by instruments and strategies contained in FICA and related regulations without substantial changes to these objectives and approaches. This picture did not change until 1983, when considerable modifications and amendments to existing regulations took place, stimulated by the dramatic increase in forest damages. This phase, still in progress, can be characterised as being a relatively clear-cut, problem-oriented air pollution control policy, because the focus of air pollution control regulations was set on major emitting sources, and a comparatively stringent timetable fixing the steps of enforcement was established. Furthermore, the means provided for implementation of the objectives were to a considerable degree more adequate than the former ones. Especially the 1983 "ordinance on large combustions plants" mandates substantial emission reductions in new and existing stationary sources. However, one basic feature of air pollution control policy remained the same, despite some minor modifications: air pollution control is basically a highly formalised, regulatory policy, implemented with traditional bureaucratic means and allowing little flexibility for emitters' efforts to make pollution control requirements less costly. In addition, the existing principle that legally allowed emissions are free of costs was not tackled: despite numerous claims by several groups a charge system was not established.

The current phase of air pollution control policy also highlights the importance of international cooperation. No systematic approach in this area has been established so far. However, certain bilateral negotiations (especially with eastern European countries) have been initiated. The important role played by the European Economic Community became clear when the EEC decided not to adopt the stringent standards for car exhausts proposed by the German federal government. The importance of the international dimension of air pollution control policy has been realized for many years, at least since reports were made on the long-range transport of air pollutants, but until recently no adequate measures have been established by the federal government. The 1982 Stockholm conference on acidification of the environment marked the beginning of a new attitude of the federal government towards international pollution control efforts. Since then, the federal government has been pushing for more rigorous implementation of the 1979 ECE convention on transboundary pollution and for a more aggressive emission abatement directive by the EEC. The 1984 "Multilateral Conference on the Environment" in Munich, initiated and organised by the federal government, might provide the starting point for closer cooperation in air pollution control between western and eastern European countries.

2. Social, Economic and Political Developments and Their Influence on Air Pollution Control Policy

The first phase of "policy design" (policy formulation), at the beginning of modern air pollution control policy in 1969, was characterised by

- o a nearly complete consensus of all relevant parties and actor groups on the need of a comprehensive, "autonomous" environmental policy. It was the then governing social-liberal coalition which took the initiative and established, in a rather short period, a thorough basis (environmental programme of 1971) for environmental legislation. Numerous groups from different societal spheres participated in designing this program;

- o influence from the activities of international organisations which took up environmental pollution as an issue (UNO, NATO, OECD, etc.) and the involvement of the German federal government from 1968 onwards in preparation for the 1972 UN conference on the environment in Stockholm;
- o a boom in environmental issue reporting in the media since 1969;
- o strong efforts of the government to get business interest groups to participate in the programme formulation (this was later emphasized by the so-called "cooperation principle" as one of the three basic principles of environmental policy). Furthermore, the strong consideration paid to business interests considerably influenced the design of environmental policy, inter alia, the polluter-pays-principle was modified to include criteria of economic feasibility, and strict liabilities were excluded;
- o the fragmentation of the general concept (media-by-media approach, e.g., air, water, soil) in contrast to an "integrated concept" on the basis of the ecological context, as was claimed by a group of scientists and nature protection organisations. However, the institutional fragmentation of responsibility at the policy level decisively influenced the fragmentation of the design;
- o the almost total lack of citizen groups interested in air pollution control and the almost complete disinterest of the political parties in actively promoting and developing environmental concepts and strategies.

The next phase of legislative activities, leading to the enactment of basic air pollution control regulations in 1974, was characterised by:

- o growing public concern over environmental pollution;
- o nearly exclusive participation from bureaucrats in drafting the law and their close cooperation with business interest groups, which decisively influenced FICA and ordinances enacted after 1974;

- o the rapidly increasing public concern about air pollution problems and a corresponding increase in citizens' initiatives centering around the issue of environmental pollution. These initiatives organised at the communal, state and federal levels in reaction to the weak response by the so-called "traditional" interest groups and political parties to citizens' demands. Citizens' initiatives ran in political elections and organised opposition against emitting sources, in particular power plants. Opposition against all kinds of new industrial and other development projects increased tremendously, in single cases involving tens of thousands of people;
- o discussion on the so-called "implementation deficit" (insufficient enforcement) in air pollution control policy for which the weak, inadequate legal instruments and the lenient enforcement activities of the competent authorities were made responsible;
- o the successful formation of "green" parties at the state level and, later on, at the national level; the "Greens" won considerable votes in elections at all three levels. They placed representatives in the assemblies of several states and gathered more votes in the national election of 1983 than the Free Democratic Party, entering the national assembly, the Bundestag, as the third of four parties.
- o growing resistance of business groups and trade unions against air pollution control measures in the wake of the economic recession accelerated by the energy price crisis of 1973. This opposition met favourable response by the federal government, which, after meeting with business interest groups and trade unions in July 1975 at Gymnich, so radically watered down environmental policy and re-directed emphasis almost exclusively on pure economic goals. The following increase in environmental action groups and the success of green parties in political elections as well as opinion polls showed that the general public was dissatisfied with this decision and its consequences;

- o a considerable increase in court action and a general involvement of courts in environmental conflicts. Court decisions (especially those of the lower courts) were sometimes in favour of environmental concerns, but there have also been decisions setting decisive restrictions on enforcement or abatement measures. All in all, although playing an important role in environmental conflicts, courts have not been able to solve the structural, legal, political and economic problems causing the conflicts;
- o the failure of the major political party to integrate the growing concern and public interest on environmental problems into their programmes, as well as in activities;
- o a comprehensive coverage of environmental problems by the public media reporting nearly daily on environmental damages;
- o the failure of lower tier authorities (at the communal level) to integrate environmental concerns into their local policies (industrial siting, urban development, energy supply, etc.). In general, local authorities gave priority to attracting industries and even refrained from studies on environmental problems in their areas for fear that the reputation of being a polluted area might entail economic disadvantages;
- o small progress in the development of abatement technologies and emphasis on the strategy of building high chimneys to reduce local pollution loads;
- o growing concern on harmful effects to human health by air pollution;
- o the discovery of extensive forest damage, which had the most decisive impact on the nation's domestic and international environmental policies.

The fourth phase of reinforced air pollution control policy began at about the end of 1982. This phase, still in progress, was mainly set in motion by the dramatic public debate on the negative consequences of air pollution to forests, human health

and the ecosystem as a whole. The then governing social-liberal coalition responded amazingly fast to the broad public consensus, which emerged in support of stricter emissions control, and to the growing political importance of the Green Party by issuing a programme entitled "Account and Perspectives of Environmental Policy" in September 1982. This ambitious new programme gave environmental policy an entirely new, extremely important dimension, which it had never had before. The most important proposals of the programme dealt with air pollution control measures. New regulations were announced, mandating substantial reduction in emissions from older, larger combustion plants by giving the choice of either closing them down within a certain number of years or installing purification equipment. In addition, strict emission standards for new emission sources were announced. This environmental programme of the social-liberal coalition was adopted almost unchanged by the subsequent government, a conservative-liberal coalition which took over power some weeks later. The new federal government implemented, in a rather short period of time, basic elements of the programme by enactment of the Ordinance on Large Combustion Plants of 1983, the amendments (revisions) of the TI Air and FICA, by initiating EEC legislation on car exhaust standards and by introducing a package of tax advantages as incentives to buy so-called low-pollution cars and lead-free petrol. Not only did the federal government's attitude to air pollution problems change, but also many state governments subsequently introduced new air pollution control programmes and increased implementation activities. Among the federal states the state of Baden-Wuerttemberg turned out to become a pace-maker in air pollution control policy. Furthermore, local authorities, especially those in areas with high pollution loads, considerably increased their activities for stricter air pollution control, sometimes even challenging powerful industrial groups, e.g., the power supply industry and the chemical industry. All in all, the influence of business interest groups on environmental policy has slightly diminished, and both public authorities

and industrial emitters are now being placed under strong pressure by the public to achieve real success in reducing emissions. At present, symbolic environmental policies--enacting ambitious programmes and laws without adequate impacts due to implementation short-falls--do not seem to have a good chance of being accepted by the public. It is also important that some of the most powerful trade unions which for a long time rather opposed than favoured strict environmental policy increasingly call for state subsidised employment and investment programmes in the area of energy saving and environmental protection.

III PRESENT AIR POLLUTION CONTROL SYSTEM: LAWS, REGULATIONS, STANDARDS, APPROACHES AND ORGANISATION

1. Introduction

The Federal Republic of Germany (FRG) is a federal state with a written Constitution (Grundgesetz), providing the eleven German states (Laender) with strong legislative and executive powers. Environmental protection responsibilities and functions must be organised according to the requirements of the constitutional order. In general, the Constitution divides powers between the federal government, the states and the local authorities (Gemeinden). In the area of pollution control, the latter only play an indirect role, e.g., in development planning (as the so-called "third parties"), submitting opinions in permit procedures, responsibilities for road construction, traffic control, energy supply and tasks delegated to them by state authorities.

The Constitution divides legislative authority between the federal government and the state in three ways. In some areas, the federal government has exclusive jurisdiction (Article 73 of the Constitution). Specific environmental matters are not covered herewith. Only the areas of federal railways and air traffic have an indirect relation to environmental protection, also the Environmental Statistics Act of 1974 is based on this provision. The federal government and the state have concurrent jurisdiction in the areas of noise abatement, exploitation of nuclear energy and radiation protection, waste disposal, and, what is important here, air pollution control (Article 74 of the Constitution). Concurrent (competing) jurisdiction means that the state may only pass laws in these areas if the federal government has not done so. Accordingly, a federal law may replace already existing laws at the state level. In 1974, the federal government used these powers to enact the Federal Immission Control Act (FICA), the basic law for air pollution control. In the third area of framework jurisdiction, such as nature

protection, regional planning, water supply (including water protection), etc., the federal government is only authorised to pass broad framework laws, which must be implemented by the individual states by their own detailed laws adapted to the specific conditions of areas under their administration.

Finally, it is important to note that the federal Constitution does not make particular reference to environmental protection; its amendment by a basic provision for a safe or healthy environment is still discussed. Therefore, the most important sources for environmental legislation are the laws passed by federal or state parliaments. In the case of air pollution control policy, the central law is the Federal Immission Control Act.

2. Responsibilities and Organisational Structures

As was noted in the introductory section above, not only legislative powers but also their execution are divided between the federal government and the state governments. The federal government did not acquire full legislative competence for air pollution control matters until a constitutional amendment in 1972 gave the federal level concurrent legislative powers with the states in this area. Prior to this, the federal government had the power only to promulgate framework laws which the states "filled in". This situation changed fundamentally with the enactment of the Federal Immission Control Act (Bundes-Immissionsschutzgesetz). Under this law, the federal executive is authorised to issue ordinances (they function like a law) and administrative rules (Verwaltungsvorschriften) serving as a binding guideline only for public authorities and not for the general public or the emitters. However, they actually affect these groups, too. In both cases of statutory and administrative regulations, the federal executive needs the consent of the State Chamber (Bundesrat), which represents the state governments. This requirement for consent is extremely important, for it serves as an effective means for the states to participate in

and to influence the basic requirements, standards and approaches of air pollution control policy. Thus, federal government has only limited actual power to independently develop and enforce a national air pollution control policy.

Apart from this limited (actual) legislative power, its power to control the implementation and enforcement activities of the state authorities is even more restricted. Implementation and enforcement of FICA is a state matter. The states, through their administrative agencies, are primarily responsible for enforcing the law. They also have the power to organise their implementation systems as they deem appropriate. Accordingly, they organise the structure of the authorities, administrative procedures (if these are not stipulated by federal administrative regulations), as well as the funding and staffing of their implementation agencies. Furthermore, there is no strong formal control provision at hand for the federal executive to force the states to perform their implementation and enforcement duties. In implementing FICA and its supplementary regulations and guidelines established by the federal executive, the states are only subject to federal control over the correct legal application. However, some influence on performance of state authorities is ensured by legal rights of those regulated (emitters), third parties and the public, who can take legal action primarily on the basis of the Civil Code (BGB), administrative law and other dispute settlement procedures. Courts can review both lawfulness and appropriateness of the activities.

As a result of the constitutional requirements for division of power between federal government and the states, the air pollution control system in the FRG is exceedingly complex. In the following, the administrative structure of air pollution control and other relevant institutions is briefly described.

2.1 Federal level

Federal laws on air pollution control must be passed by both the Federal Parliament (Lower House = Bundestag) and the State Chamber (Upper House = Bundesrat). Regulations and administrative rules developed by the executive branch (Bundesregierung) or the federal ministries, as a rule, require consent of the State Chamber.

There are several federal ministries involved in air pollution control policy but, in general, and for the most important cases, the responsible ministry is the Ministry of the Interior (Bundesministerium des Innern). It coordinates the environmental policies of the federal government, including environmental planning, nuclear reactor safety, radiation protection, waste and water management, international cooperation in environmental matters, etc., and air pollution abatement. It is responsible for issuing statutory and administrative regulations on the basis of FICA. According to its range of tasks in environmental protection matters, it can be considered as the Ministry of the Environment. Within the ministry, environmental protection matters are the responsibility of the "Division of Environmental Protection" (Umweltabteilung), which is divided into three sub-divisions, which are further sub-divided into units responsible for particular aspects of the respective areas of concern. Sub-division U I handles general environmental affairs (like planning, coordination, international affairs, economics, etc.); sub-division U II is responsible for water resource management; and sub-division U III is in charge of noise abatement and air quality conservation.

Subordinate to the Ministry of the Interior is the Federal Environment Agency (Umweltbundesamt), established by law in 1974 (approx. 450 employees). It functions mainly as a research and advisory body. Central responsibilities cover, for example, the development of an environmental planning and information system, research on technological and

scientific data to support the development and implementation of environmental policies, providing scientific assistance to the federal government in matters of air quality control, and, in particular, for the preparation of statutory and administrative regulations, information for the public on environmental matters, etc. The agency also manages a special monitoring network for monitoring air quality in "rural" areas for obtaining information on background pollution. In accordance with the legal division of functions between the federal government and the states, the agency cannot issue any regulation or perform control functions. Since its establishment in 1974, the agency has gained tremendous importance as an information centre for government and private organisations, as well as individuals and the public. Some of its reports on pollutants have deeply influenced the public discussion and implementation of counter-measures.

The Institute for Water, Soil and Air Hygiene, also subordinate to the Ministry of the Interior, is mainly concerned with research in the fields of human ecology, water, soil and air hygiene, etc.

Coordination of federal environmental programmes is conducted by the Cabinet Committee for Environmental Questions, chaired by the Federal Chancellor (Bundeskanzler), with members from all federal ministries involved in environmental protection. The "permanent board of the heads of divisions for environmental matters" coordinates environmental policy and implementation in the federal government and between the states and the federal government. The Conference of federal and state minister responsible for the environment (including the Federal Ministry of the Interior) is the major committee for coordination of state and federal environmental policy and information exchange. Furthermore, a special joint federal-state committee on air pollution and noise does similar work with a stronger emphasis on air pollution.

As mentioned above, the Ministry of the Interior can be considered as the Ministry of the Environment; but other federal ministries are also involved in air pollution control matters: so, for example, in energy policy and the economic implications of environmental protection policies, the Federal Ministry of Economics; in land use policy and regional planning, the Ministry for Town and Regional Planning; in nature conservation and pollution of water, air and soil from agriculture and forestry, the Federal Ministry of Agriculture, Forestry and Food; in transportation and the environment, the Federal Ministry of Transport; in coordinating research and developing air, water, soil, etc. pollution control, low-pollution technologies, etc., the Federal Ministry for Research and Technology, to name just the most important ones. (Note: in June 1986 a fundamental reorganisation was undertaken as indicated in the last paragraph of this page.)

Although there are special forums and committees for coordination and information exchange among the several ministries at the federal level, the fragmentation of responsibilities and powers often leads to coordination problems and conflicts among the departments involved. This makes it difficult to develop a comprehensive and consistent air pollution control strategy. Conflicts and coordination problems primarily result from different views on policy priorities among the ministries. In particular, the Ministry of Economics often is in strong opposition against strict air quality control regulations for its "clientele".

To overcome these problems impeding rational and efficient environmental policies, suggestions have been made to establish an environmental "super-ministry" taking over all environment-related responsibilities. However, it was not until after the disastrous nuclear accident at Chernobyl in April 1986, which dramatically exposed the fundamental incapacibilities of the federal government to cope with environmental emergencies, that a major reorganisation of responsibilities was undertaken: in June 1986, government founded the Ministry for the Environment, Nature Protection and Reactor Safety.

2.2 State level

The state governments are not only responsible for implementation and enforcement of FICA, they also can enact laws and regulations as well as issue directives concerning air pollution control. The state governments have great latitude in air pollution control policy decisions, especially concerning the selection of approaches and strategies offered by the federal law, and in setting their own priorities in air quality management. For example, they organise their own systems for air pollution alerts (e.g. in smog situations), establish monitoring networks and develop and implement "clean air programmes". Thus, the actual authority for air pollution control in the FRG rests with the eleven states.

To administer the responsibilities under environmental legislation, state governments have designated the authorities responsible for implementation and supervision of air pollution control policies. Since the responsibility for organising enforcement generally rests with the eleven states, there is no uniform implementation system. Some states have a special ministry of the environment, while others have divided the responsibilities among several departments. In general, responsibilities in the area of air pollution control are divided between the general administration (ministries, district administrations, county administrations) and the technical agencies (factory inspectorates = Gewerbeaufsichtsämter), but some states have organised administrative and technical tasks in one department. All systems have their advantages and disadvantages. For example, where responsibilities are divided, the general administration is highly dependent on information from technical agencies and can thus be "manipulated" by them, in particular, since technical agencies sometimes have deep-rooted relationships to the emitting factories concerned. Departments of the general administration, as a rule, are better able to coordinate the efforts of several agencies, although they are technically less competent. Technical agencies are characterised by a

high level of expertise, and, at the same time, a high dependency on cooperation with industry. Consequently, most permit procedures are determined by close cooperation between industry and the responsible agency, resembling a bargaining situation. Negotiations between the ministry and the agency begin long before an application for a permit is filed. Since pre-negotiations are conducted internally, no public participation is possible at this stage. Thus, the essential decisions are made without participation of residents of the area concerned ("neighbours") or the general public. Later on, in the formal permit procedure, when citizens are allowed to participate and to voice their concerns or interest, it is often too late to influence the design of the proposal determined during the informal pre-negotiation phase.

To sum up: The organisational structure (state implementation systems) for air pollution control varies considerably among the eleven states, both with respect to the vertical division of functions (between ministries and lower-tier authorities) and the horizontal division of functions (between ministries, agencies and authorities at the same hierarchical level).

2.3 Local level

As mentioned above, the influence of lower-tier authorities (local authorities) as well as their general responsibilities in air pollution control policies are rather limited. Most of their competence is delegated to them by state authorities. Accordingly, their activities are closely supervised and controlled. Thus, they play only a minor role in implementation and enforcement of air pollution control legislation. Finally, it should be mentioned that the role of local government in air pollution control varies greatly among the states.

2.4 Other institutions

The "Council of Environmental Advisors" (Sachverständigenrat für Umweltfragen) is an independent committee of experts to

advise the Minister of the Interior on environmental issues. It periodically issues special reports on major issues of environmental policy, and, so far, it has published two comprehensive reports on the state of the environment (Umweltgutachten).

Environmental policy-making is also supported by close cooperation between governmental agencies and several private, professional organisations, which provide (mostly technical) standards and guidelines. Among these the Association of German Engineers (VDI) with its Clean Air Commission plays the most important part. So far, more than 200 guidelines have been published. They do not have legal force but, in practice, they are often used as references for defining what is technically feasible. The Clean Air Commission is not open to public participation; therefore, critics indicate that their standard-setting process and its outcome are strongly influenced by experts from private industry.

2.5 Courts

Courts play an important role in implementation and enforcement of air pollution control legislation. This is particularly true for the "administrative courts" (Verwaltungsgerichte), which decide cases involving public law. They hear cases brought by private persons to prevent, control or repeal action by a government agency or private organisation carrying out public functions. Emitters also quite often take legal action on the basis of administrative law. Taking legal action is only possible if the injured party's rights have been (unlawfully) harmed by an administrative action (or non-action: Verpflichtungsklage). There are three levels of administrative jurisdiction: administrative courts, higher administrative courts and the federal administrative court. Possibilities for taking legal action against air pollution and the damages therefrom also follow from the Civil Code; these cases have to be brought before the regular courts (four-level hierarchy). Decisions of the administrative

courts have, in some cases, decisively influenced air pollution legislation and policy. The criminal law plays a comparatively minor role in the area of air pollution as well as in environmental matters in general. Recently published studies show that although the number of environmental offenses has increased enormously (from 1973 to 1984 by approx. 310%) only a few cases are actually brought to court. In 1984, 9,805 environment-related violations of criminal law were registered; in 1985, about 12,000 cases were counted. Most of the proceedings are quashed, in particular those involving air pollution. Moreover, only a few environmental polluters from the industrial sector have actually been convicted. Fines inflicted upon polluters are usually so low that they have almost no effect as deterrents. From 1981 to 1983, only 67 sentences requiring imprisonment were passed; 48 of these were suspended. (For comparison: in Japan, between 1979 and 1983 about 5,660 environmental offenders were arrested per year.)

3. Laws and Regulations

Compared to other European countries, the laws and regulations for air pollution control in the FRG are most comprehensive and detailed. Since the beginning of the 1970s, federal and state legislatures and governments have enacted numerous laws, regulations, guidelines, technical instructions and other directives covering the whole area of air pollution control, including standards, substantial policy matters, legal provisions for third parties and the public, technical matters such as monitoring and sampling devices, etc., and procedural rules. There is a strong tendency, rooted in the specific politico-administrative culture of the FRG, to strive for an almost loophole-free system of legal regulations for all aspects of programme formulation, implementation and enforcement in the area of air pollution control. Existing laws and regulations have been repeatedly amended and made more detailed. As a result of all these legislative and norm-setting activities, air

pollution control policy in the FRG is based on a "full national programme", which means all dimensions of this policy area are covered by formal rules. (The programme dimensions making up a full national programme are: administrative instruments and procedures, organisation, financing; emission, product and process standards, ambient air quality standards and goals; monitoring and reporting requirements.) Thus, the present air pollution control system in the FRG not only is characterised by its highly complex organisational structure, but also by its tremendously complex and detailed legal and other requirements. The relevant paragraphs to be taken into consideration in air pollution control policy cover hundreds of pages and even legal and administrative experts admit that it is extremely difficult for them to get a full understanding of the total system.

The following section provides an overview of the most important federal laws and regulations for air pollution control and air quality management. Bylaws issued by state and local authorities (Satzungen) as well as those laws from other policy subjects with an indirect influence on air quality management (e.g., land use planning, energy supply) are not included here for practical reasons; they can be easily drawn from the numerous comprehensive handbooks and legal digests covering the whole area of environmental protection.

3.1 Overview

The basic air pollution control law is the Federal Immission Control Act of 1974 (complete title: "Act for Protection from Harmful Environmental Effects of Air Pollution, Noise, Vibration and Similar Occurrences"), last amended in 1985. The following ordinances (Rechtsverordnungen) are based on this act:

- first ordinance for implementation of the FICA (Ordinance on Furnaces) of 1974,
- second ordinance for implementation of the FICA (Ordinance on Dry-Cleaning Facilities) of 1974,

- third ordinance for implementation of the FICA (Ordinance on the Sulphur Content in Light Fuel Oil and Diesel Oil) of 1975,
- fourth ordinance for implementation of the FICA (Ordinance on Facilities Subject to Licensing) of 1975,
- fifth ordinance for implementation of the FICA (Ordinance on Immission Control Experts) of 1975,
- sixth ordinance for implementation of the FICA (Ordinance on Professional Knowledge and Reliability of Immission Control Experts),
- (seventh and eighth ordinance not relevant for this study),
- ninth ordinance for implementation of the FICA (Ordinance on Principles for Licensing Procedures) of 1977,
- tenth ordinance for implementation of the FICA (Ordinance on Restrictions on PCB, PCT and VC) of 1978,
- eleventh ordinance for implementation of the FICA (Ordinance on the Emission Inventory Declaration) of 1978,
- twelfth ordinance for implementation of the FICA (Ordinance on Hazardous Incidents) of 1980, and
- thirteenth ordinance for implementation of the FICA (Ordinance on Large Combustion Plants) of 1983.

Based on the Federal Immission Control Act and its ordinances, numerous administrative guidelines and circulars specifying various aspects of the law and its regulations have been passed in order to guarantee uniform implementation in all federal states. The most important ones are:

- first general administrative regulation under the FICA (Technical Instruction for Maintaining Air Purity) of 1974, substantially amended in 1983 (part 2, main subject: ambient air quality standards) and in 1986 (part 3, main subject: emission limits, existing stationary emission sources),
- fourth general administrative regulation under the FICA (Monitoring of Ambient Air Quality in Designated Areas) of 1975,
- fifth general administrative regulation under the FICA (Emission Inventories in Designated Areas) of 1979.

Finally, the following laws deal with specific matters of air pollution control:

- the Act on Environmental Statistics of 1974,
- the Act for the Reduction of Air Pollution from Lead Compounds in Motor Vehicle Fuels (Lead in Petrol Reduction Act) of 1971,
- the Act on Tax Measures for the Promotion of Low-Emission Passenger Cars of 1985.

As the FRG is a member of the European Economic Community (EEC), environmental regulations and directives of this supra-national institution are also of importance to West German air pollution control policy. On the basis of the EEC treaty, the Council and the Commission of the European Community can influence air pollution control policies: regulations and directives of the EEC can replace national air pollution control regulations or have to be implemented like national regulations. Among the more than 40 environmental directives enacted by the EEC there are several directives relevant for air pollution control policies in the member states:

- Directive on motor vehicle emissions of 1970, repeatedly amended, last amendment in 1985 (adoption of the latest amendment is still (June 1986) blocked by Denmark and Greece),
- Directive on lead content of petrol of 1978 (No. 78/611/EEC),
- Directive on air quality limit values and guide values for SO₂ and suspended particulates of 1980 (No. 80/779/EEC),
- Directive on a limit value for lead in the air of 1982 (No. 82/884/EEC),
- Directive for combatting air pollution from industrial plants of 1984 (No. 83/173/EEC),
- Proposal for a directive on the limitation of emissions from large combustion plants of 1983 (No. 83/704/EEC); not yet adopted,

- Directive on the assessment of the environmental effects of certain public and private projects of 1985 (No. 80/313/EEC),
- Directive on air quality standards for nitrogen dioxide of 1985 (No. 83/498/EEC),
- Proposal of 1985 (No. 85/377/EEC) for a directive amending Directive 75/716/EEC on the sulphur content of certain liquid fuels, not yet adopted (March 1986).

The FRG is one of the signatories of the Geneva Convention on Long-Range Transboundary Air Pollution (effective March 16, 1983) and also a member of the so-called "30%-Club". The 21 members of this club have committed themselves to reduce their annual sulphur emissions by at least 30% as soon as possible, by 1993 at the latest. The reference year is 1980. Some "club members" even promised further reductions. The FRG, for example, aims at a 60% reduction until 1993.

3.2. Basic standards, regulations and approaches in air pollution control

Based on the legal material listed in section 3.1, this section provides an overview of the substantial contents of the laws and regulations and the fundamental approaches for air pollution control in the FRG.

The overall objective of environmental policy in the FRG is expressed in the government's "Environment Programme" of 1971. According to this programme, the environmental policy of the West German government is based on three basic principles:

- o Prevention principle: Environmental policy is not limited to preventing immediate threats and removing damage that has already been caused, but demands that considerable efforts be made in order to prevent the occurrence of environmental damage in the future.

- o Polluter pays principle: Costs incurred in preventing or offsetting environmental impacts are to be borne by the polluter.
- o Cooperation principle: Environmental policy shall be developed in close cooperation between all relevant parties, i.e., this principle requires that in the process of preparing regulations and administrative orders a hearing should be held, which shall include all parties concerned. These parties usually are representatives of federal, state and local administration, science, economy (large firms, business federations) and citizens' organisations.

These basic principles were established before air pollution control policy by FICA and the pertinent regulations began. The primary objective of FICA and air pollution control policy, in general, is to protect human beings as well as animals, plants and other objects from harmful effects on the environment and, insofar as facilities subject to licensing are concerned, from danger, considerable disadvantages and nuisances caused in other ways, and to prevent such harmful effects on the environment.

In order to make these ambitious but rather vague general objectives "manageable" with regard to maintaining and improving the quality of the air, FICA includes the following strategies in combination with standards:

- o Ambient air quality standards: By setting ambient air quality standards it shall be avoided that tolerable concentrations of pollutants in the ambient air are exceeded by the establishment of new emitting facilities or by expansion or considerable modification of existing facilities.
- o Emission standards: According to the principle of prevention, emissions of pollutants have to be controlled in such a way that the application of all possible emission reduction measures--taking into account the best control technology available as well as its economic feasibility--

is assured in every single case regardless of the ambient air quality situation in the area. Thus, the prevention principle is also applied in areas with relatively good air quality. Emission levels considered achievable through the application of appropriate technology are fixed by concrete emission standards. So far, emission standards for maximum concentrations of about 170 air pollutants (specified for over 40 types of facilities) are established.

At present there are only 8 ambient air quality standards for protection against health hazards and 5 ambient air quality standards for protection against considerable disadvantages and substantial impairment (see table 5).

Numerous highly technical and complex articles in the Technical Instruction for Maintaining Air Purity (TI Air) contain requirements for monitoring and assessing these standards. It should be mentioned that the establishment of ambient air quality standards by general administrative decree (TI Air) and not by statutory rule (Rechtsverordnung) or law (Gesetz) gives them a somewhat ambivalent legal status because the TI Air is only binding to the administration but not the courts. Therefore, in conflict cases, the ambient air quality standards are principally open to courts' interpretation whether or not they fulfill the principal requirements of FICA. However, a court case which was finally decided by the (highest) Federal Administrative Court (the so-called Voerde decision) held that the ambient air quality standards can also be considered by courts as the state of the art of present scientific knowledge on harmful effects of the respective pollutant. Correspondingly, ambient air quality standards are also, to a high degree, binding to the courts and only open to interpretation by them if certain substantial preconditions are not fulfilled (e.g., if the court can show that the pollution limit value was not based on existing scientific knowledge or that new scientific findings require a revision).

TABLE 5
 OLD (1974) AND NEW (1983) AMBIENT AIR QUALITY STANDARDS

Substances	TI Air 1974		TI Air 1983			
	IW 1	IW 2	Health		Impairment etc.	
IW 1: long-term standard	IW 1	IW 2	IW 1	IW 2	IW 1	IW 2
IW 2: short-term standard						
SPM (without materials, incl.) mg	0.10 ¹ 0.20 ²	0.20 ¹ 0.40 ²	0.15	0.30		
Lead, inorganic compounds in SPM - Pb - $\mu\text{g}/\text{m}^3$	-	-	2.0	-		
Cadmium, inorganic Cd-compounds in SPM - Cd - $\mu\text{g}/\text{m}^3$	-	-	0.04	-		
Chlorine mg/m^3	0.10	0.30	0.10	0.30		
Hydrochloric acid - Cl - mg/m^3	0.10	0.20 ³	0.10	0.20 ³		
CO mg/m^3	10.0	30.0	10	30		
SO ₂ mg/m^3	0.140	0.40	0.14	0.40		
NO ₂ mg/m^3	0.10	0.30	0.08	0.30		
Dust fall (non-hazard.) g/(m ² d)	0.35	0.65			0.35	0.65
Lead, inorganic lead in dust fall - Pb - $\text{mg}/(\text{m}^2\text{d})$	-	-			0.25	-
Cadmium, inorganic Cd-compounds in dust fall $\mu\text{g}/(\text{m}^2\text{d})$	-	-			5	-
Thallium, inorganic Tl-compounds in dust fall $\mu\text{g}/(\text{m}^2\text{d})$	-	-			10	-
Hydrofluoric acid, inorg. gaseous fluorine comp. $\mu\text{g}/\text{m}^3$	2.0	4.0			1.0	3.0
Hydrogen sulfide mg/m^3	0.0050	0.010				
NO mg/m^3	0.20	0.60				

- 1) Particles below 10 μm 2) Particles above 10 μm
 3) As long as hydrochloric acid cannot be measured clearly separated from chlorides, IW 2 shall be 0.30 mg/m^3

Source: S. Kalmbach 1983 and TI Air 1983

Apart from the aforementioned "conflict cases", ambient air quality standards serve as yardsticks in judging the FICA's general directives and their appropriateness for avoiding harmful or detrimental effects of pollutants. On the basis of these standards it is decided whether new emitting facilities above a certain size can obtain the required licence, whether existing emission sources should be forced or encouraged to adopt stricter pollution abatement measures and whether the responsible authorities have to set up so-called Air Quality Maintenance Plans to assure compliance with ambient air quality standards.

The basic objectives of FICA as operationalised by ambient air quality standards, and the "precautionary" (prevention) principle to reduce emissions according to the best control technology available independent of the existing ambient air quality, are implemented by several more or less inter-related approaches established by the laws and regulations listed in section 3.1. The following basic approaches can be found:

- o facility-related measures,
- o area-related measures,
- o product-related measures,
- o measures related to mobile sources,
- o general supplementary and supporting measures.

3.2.1 Facility-related measures

Industrial and trade facilities potentially harmful to the environment to a certain extent may not be operated without a licence. Approximately 100 facilities subject to licensing are listed in the Fourth ordinance for implementation of the FICA. The fundamental principles of the licensing procedure have been set down by the Ninth ordinance for implementation of the FICA. It is not permitted to construct and operate any of these listed types of industrial plants without a licence. Not only new facilities are subject to approval, but also large-scale alterations of existing ones.

In order to provide a uniform practice, interpretation and application of FICA, the Technical Instruction for Maintaining Air Purity (TI Air) was enacted in 1974 and substantially amended in 1983 and 1986. The TI Air includes, inter alia, the following instructions for licensing:

- o ambient air quality standards for key pollutants,
- o emission standards for more than 170 air pollutants combined with the general requirement to apply the best pollution control technology available,
- o specification of methods and instruments for determination, assessment and evaluation of ambient air quality

and for calculation of dispersion of emissions in the atmosphere (stack height formula).

The most rigorous control requirements apply to new emitting sources (licensed after 1974) regarded as heavily polluting. Operators of such facilities must obtain, under a highly complex and usually time-consuming procedure, a licence by the responsible state authorities. During the licensing procedure the responsible authority must investigate whether the requirements of FICA are fulfilled. To ensure compliance with these requirements the responsible authority can grant a licence subject to conditions and restrictions. If compliance cannot be ensured the licence will not be issued.

The normal licensing procedure is open to public participation. The application for a licence and associated documents are publicly displayed for two months, except for documents containing business secrets. During this period anyone can place objections against the development with the responsible authority. Once a licence is granted, only those with a direct interest are allowed to initiate court procedures. The applicant (emitter)--if not satisfied with the authority's decision--can also apply for a court decision. The involvement of administrative courts in conflicts with licence-granting processes is quite a common feature.

The responsible licensing authority shall also obtain the opinion of any other authority whose area of competence is affected by the project. After the period specified for objections has elapsed, the licensing authority must discuss the objections to the project with the applicant and with those who have lodged the objections (a process rather similar to a public hearing). The decision on the application for a licence shall be issued and the grounds stated in writing; it shall be served upon the applicant and the persons having lodged objections. If more than 500 persons are involved, such service may be replaced by public notice.

For installations of a certain type and size as specified in the fourth ordinance licences may be issued under a simplified procedure. This procedure is not open to the public and no formal objections can be raised. Only injured parties can make complaints against the licence on the grounds of both civil and public law.

There are no formal licensing requirements for small and medium installations. There is, however, a general legal provision that such installations must avoid harmful environmental effects according to the latest state of technology or that environmental effects which cannot be avoided be reduced to a minimum. Even if installations do not require licensing, their construction and operation are subject to certain regulations (such as the first ordinance for implementation of the FICA regulating the design, installation, and operation of furnaces using solid or liquid fuels). And, of course, they are subject to requirements by general laws and regulations, especially the building law.

Before the recent amendments of FICA and TI Air, older emitting facilities and those licensed according to FICA prior to its amendment were treated in quite a different way than new sources. Existing facilities were only subject to almost the same formal requirements when a significant modification was applied for. For all other large emitting sources Article 17 of FICA stipulated that in cases where the general public or the vicinity are not adequately protected from harmful effects on the environment or other dangers, the responsible authority shall give subsequent directions (so-called abatement or clean-up orders). But these additional requirements could not be enforced if any investigation of the case showed that such measures would not be economically justifiable for the owner (economic feasibility) or could not be carried out according to the latest state of pollution abatement technology. In practice, these restrictions have almost excluded existing pollution sources from additional requirements. Therefore, one of the most important legal provisions for

cleaning up polluted areas was, until recently, almost meaningless. This situation changed with the enactment of the thirteenth ordinance for implementation of the FICA, the Ordinance on Large Combustion Plants of 1983, which imposes stricter emission reduction requirements on installations with a capacity of more than 50 MW(th), and with the amendments to FICA and the TI Air.

The Ordinance on Large Combustion Plants fixed new emission standards: for combustion plants with a capacity of more than 300 MW(th) the emission standard for SO_2 is now 400 mg/m^3 . In addition, it is stipulated that such facilities must attain a degree of flue gas desulphurisation of at least 85%. The emission standard for nitrogen oxides is 800 mg/m^3 combined with the obligation to use any possibility for further reduction of emissions through furnace improvements or other technical measures corresponding to the state of the art of technology. The Conference of federal and state ministers responsible for the environment (Umweltministerkonferenz) took a basic policy decision on April 5, 1985, according to which combustion plants with a capacity of more than 300 MW(th) will only be licensed if their nitrogen oxide emissions, in terms of NO_2 , do not exceed 200 mg/m^3 in the case of coal firing, 150 mg/m^3 in the case of oil firing, and 100 mg/m^3 in the case of gas firing. In principle, old combustion plants should also comply with these values at the earliest possible date if operation is to be continued for an unlimited period.

The ordinance also covers old plants, mandating substantial SO_2 reductions on a temporal basis. Operators are hereby forced to either refit their installations within certain transitional periods (ten years at the latest) or to close them down within five years. This obligation affects about 1,500 large combustion plants. Of these, the larger plants have to be fitted with flue gas desulphurisation facilities if the operator decides to continue to run them for an unrestricted period. The group of the smallest installations

covered by the ordinance is allowed to switch to low sulphur fuel instead.

Since the enforcement of the ordinance, all new large combustion plants have had to install flue gas desulphurisation units. Smaller plants are only allowed to use low-sulphur fuel. According to official statements, the ordinance will lead to a cut in annual SO_2 emissions in the FRG by 50%, from 3.2 million tonnes in 1980 to approximately 1.6 million tonnes in 1993. Total investment costs for aiming at this goal are estimated to be about 10 billion DM or more. The Federal Environment Agency estimates that by implementation of the ordinance emissions of nitrogen oxides from large combustion plants will be reduced from presently about 1 million tonnes per year to 0.3 million tonnes per year by 1993 (= 70%).

The Technical Instruction for Maintaining Air Purity (TI Air) of 1974 was substantially amended in 1983 and 1985. Especially the ambient air quality provisions underwent significant changes (TI Air 1983). For the first time, ambient air quality standards for lead, cadmium and thallium were established, also emission standards for carcinogenic substances were made stricter. Ambient air quality standards for SO_2 remained, however, unrevised although scientists almost unanimously agree that they are too weak to prevent harm to the natural environment. With the amendment the basic principles and requirements for licensing facilities and for monitoring and assessing ambient air quality were modified. Furthermore, the maximum allowable stack height was fixed at 250 metres. The second amendment of the TI Air in 1985 (effective in March 1986) aims at tightening emission standards in accordance with the advanced state of the art. For some pollutants, emissions standards are considerably stricter now, e.g., for benzene 5 mg/m^3 (old standard: 20 mg/m^3), arsenic 1 mg/m^3 (old: 20 mg/m^3), cadmium 0.2 mg/m^3 (old: 20 mg/m^3). The second amendment covers almost all areas of industry, in particular, blast furnaces, steel works,

lead smelters, coke ovens, cement works, chemical plants, oil refineries, combustion plants with a capacity of less than 50 MW(th) (not covered by the Ordinance on Large Combustion Plants), etc. All in all, the TI Air of 1985 covers about 50,000 small and medium plants. Regulations for enforcing clean-up and abatement measures in existing emitting sources have been improved. In general, old plants are required to meet the new standards within five years, in severe cases within three years. In cases of moderate pollution a transitional period of eight years may be granted. A further reduction in annual SO₂ emissions of 180,000 tonnes, in addition to that initiated by the Ordinance on Large Combustion Plants, is expected from these measures (estimated reduction for dust: 160,000 tonnes per year, for NO_x: 100,000 tonnes per year). It is expected that with the implementation of the TI Air of 1985 investments of about 10 billion DM will occur. The new regulations also allow for the use of more flexible instruments, e.g., the creation of so-called compensatory groups (Sanierungsgemeinschaften), in which several plants of one or several owners in a given area may "pool" their emissions provided that the resulting emission level is lower than the emission level required by the new regulations for individual sources. Operators of old stationary sources, for example, who cannot meet the new standards or only with unreasonably high costs now have the opportunity to negotiate for "emission credits" from plants operated well below the required emission level. "Pools of emitters" have to submit sanitation plans to the responsible authority. It should be mentioned that the development of the TI Air of 1985 was accompanied by a heated political debate. The State Chamber (Bundesrat) had urged the federal government to modify large parts of the TI Air draft in favour of better environmental protection. But, in the end, the majority of the State Chamber (i.e., all CDU/CSU-governed states) generally accepted the government's proposal against the votes of SPD-governed states.

In October 1985, the Federal Immission Control Act (FICA) was also amended improving provisions to reduce emissions from those facilities not in line with the state of pollution abatement technology. In particular, the restrictive requirement that clean-up orders must consider economic feasibility was replaced by principles more favourable to environmental protection. It is now required that there should be a reasonable relationship between the cost for clean-up measures and their effects.

For the enforcement of air pollution control regulations the responsible authorities are provided with special legal devices to safeguard the environment and to control compliance with the law, such as monitoring, inspections, injunctions, fines, penal sanctions, temporary production stops or revocation of licences. Representatives of responsible authorities must be given access to the premises of the factories to take samples and carry out measurements. In most cases, however, operators of facilities can appeal against such decisions of an authority or file suit in the administrative court. In addition, enforcement of pollution control is a state matter. Therefore, among the eleven states, the enforcement behaviour of public authorities may vary considerably according to the different strategies chosen and the different preconditions (e.g., the general economic situation and the main types of emission sources in an administrative area).

3.2.2 Area-related measures

The area-related measures aim at the maintenance of a certain air quality in less polluted areas and an improvement of the air quality in heavily polluted areas. For maintaining air quality, state governments are authorised by FICA to stipulate by ordinance that in designated areas requiring special protection from harmful air pollution effects certain installations may not be established at all, or may only be operated at specific times, or must meet specific technical requirements

The following measures, inter alia, apply to heavily polluted areas, that is, regions where air pollution is heavy enough to cause or can be expected to cause environmental harm: designation of heavily polluted areas by the responsible state authorities, systematic and continuous monitoring of emissions and ambient air quality, and finally the establishment of the so-called "Clean Air Plans".

According to official announcements and considering their central position in the FRG's air pollution control law as well as the comprehensive and detailed legal provisions for them, Clean Air Plans constitute a basic administrative instrument in air pollution control policy. They contain inventories on emissions, the ambient air quality and effects, an assessment of the situation, forecasts on emission and ambient air quality trends and an action plan of measures to improve air quality.

The establishment of a source and emission inventory is one core element of a clean air plan. With these inventories the main emitters of air pollutants are identified and the quantities of emitted pollutants determined. The fifth ordinance for implementation of the FICA stipulates detailed requirements for such inventories. The final step of a clean air plan, actions for improving air quality, is the outcome of all information provided by previous steps. It should state measures for remedial and precautionary actions to reduce air pollution.

However, clean air plans themselves do not have the force of law; thus, they are enforceable only on the basis of existing "normal" legal provisions for pollution abatement measures or where state government has adopted specific requirements under separate authority. Therefore, in practice, clean air plans primarily function as a tool for information gathering and dissemination as well as planning.

In the following, an overview will be given on the state of implementation of the area-related approach of air pollution control policy as provided for by the legal and administrative instrument of clean air plans:

According to FICA, clean air plans must be drawn up by the responsible authorities for areas where ambient air quality monitoring data indicate such heavy pollution loads that harmful effects on the environment have occurred or can be expected to occur. This actually means that clean air plans can only be set up in areas which, by state government ordinance, have been designated as "heavily polluted areas". The "states' committee on immission control" (Länderausschuß für Immissionsschutz) has provided criteria for the determination of "heavy pollution loads". These are, inter alia, non-compliance with the ambient air quality standard for one pollutant or identification of environmental damage. Up to now, six states have designated by ordinance a total of 21 areas as heavily polluted and therefore subject to clean air plans. These states are Bavaria, Berlin, Hesse, North Rhine-Westphalia, Rhineland-Palatinate and Saarland. In addition, six areas have been designated as so-called super-vised areas for which at least an emission inventory must be established. In sum, 27 areas totalling 9,000 km² (3.4% of the total area of the FRG) with 16 million inhabitants (more than 25% of the total population) are subject to clean air plans or other area-related clean air measures (see table 6).

Table 6 shows that, as yet, clean air plans have not been established for all areas designated as heavily polluted. There is mainly one reason for this "implementation gap": the preparation and implementation of clean air plans is tremendously time-consuming and costly. In addition, it has turned out to be quite difficult to enforce subsequent improvement orders (nachträgliche Anordnungen) with existing pollution sources. All in all, clean air plans have not brought about the expected improvement of air quality, and, considering the costs, the effects are all the more disappointing.

TABLE 6
AREAS IN THE FRG DESIGNATED AS HEAVILY POLLUTED OR SUPER-
VISED AREAS

State/Area	Designated Areas in km ²	Clean Air Plans	Emission Inventories
Bayern			
Aschaffenburg	736	—	—
Augsburg	228	—	—
Burghausen	65	—	—
Erlangen-Fürth-Nürnberg	419	proposed	1982
Ingolstadt-Neustadt-Kelheim	541	—	—
München	822	—	—
Regensburg	55	—	—
Würzburg	63	—	—
Berlin	480	since 1981	1981 ²⁾
Hessen			
Untermain	466	proposed	1982
Rhein-Main	122	1981 bis 1986	1978
Wetzlar	49	—	1982
Kassel	148	—	1983
Nordrhein-Westfalen			
Rheinschiene Süd	649	1982 bis 1986 ⁺)	1984
Rheinschiene Mitte	356	1982 bis 1986	1982
Ruhrgebiet West	711	1978 bis 1982	1978
Ruhrgebiet Mitte	765	1980 bis 1984	1980
Ruhrgebiet Ost	712	1979 bis 1983	1979
Rheinland-Pfalz			
Ludwigshafen-Frankenthal	126	1979 bis 1984	1979
Mainz-Budenheim	96	1982 bis 1987	1978
Saarland			
Dillingen	8	—	1978/1983
Völklingen	35	—	1978/1983
Saarbrücken	42	—	1978/1983
Neunkirchen	31	—	1978/1983
SUPERVISED AREAS			
Baden-Württemberg			
Karlsruhe	—	—	1980
Mannheim	—	—	1980
Südlicher Oberrhein	—	—	in prepar.
Mittlerer Neckarraum	—	—	in prepar.
Niedersachsen			
Braunschweig	—	—	proposed
Hannover	—	—	proposed
Oker/Harlingerode	—	—	1983
Nordenham	—	—	1984
Salzgitter	—	—	1984
Hamburg	—	proposed	in prepar.
Schleswig-Holstein			
Brunsbüttel	—	—	1983

+) Follow-up clean air plan (of clean air plan 1977-1981)

Source: 3. Immissionsschutzbericht der Bundesregierung 1984.

The smog alarm system is a further important area-related pollution control measure provided for by FICA. In contrast to clean air plans, however, it does not aim at improving air quality but serves as a means to inform and caution the public. Smog alarms are given when high levels of air pollution coincide with weather conditions impeding air circulation and thereby building up pollution loads which may have immediate health effects. State governments are authorised by FICA to designate by ordinance areas in which such incidents are likely to occur. In these areas, the responsible authorities can prescribe special measures to be taken during smog episodes, such as restrictions on traffic, fuels and operating hours of emitting facilities. Until now, nine states have enacted smog ordinances: Baden-Wuerttemberg, Bavaria, Berlin, Lower Saxony, North Rhine-Westphalia, Saarland, Hesse, Hamburg and Rhineland-Palatinate. Smog regulations only apply to certain areas within these states, except for Hamburg and Berlin where they apply to the whole administrative area. All smog ordinances are quite similar in content as they are based on the same design developed in 1984 by the conference of the federal and state ministers responsible for the environment (Umweltministerkonferenz). Smog alarm can be given at one of three levels, aside from a pre-warning, depending on the severity of pollution. The established thresholds for issuing a pre-warning or a smog alarm are rather high. Thus, despite frequent high pollution episodes in some areas, smog alarms rarely have been given. This obvious shortcoming of the smog ordinances led, in 1984, to a revision of the reference model. The new formula set stricter thresholds, and shortly after enforcement of the new regulation, in January 1985, smog alarms occurred in North Rhine-Westphalia, Hesse, Hamburg and Bavaria. In 1986, pre-warnings had to be given in several other areas. The basic shortcoming of the smog regulations, however, has not been eliminated: they only take effect when pollution loads are already high, they do not include any precautionary measures to be taken before an actual smog alarm must be given, i.e. at the pre-warning level.

TABLE 7
INCIDENCES OF SMOG ALARM IN THE FRG

Date	Area	Stage of alarm
Jan. 1, 1979	western Ruhr region	stage 1
Jan. 1, 1980	West Berlin	stage 1
Jan. 24, 1980	West Berlin	stage 1
Dec. 16, 1981	West Berlin	stage 1
Jan. 11, 1982	West Berlin	stage 1
Jan. 19, 1982	West Berlin	stage 1
Feb. 25, 1982	West Berlin	stage 1
Jan. 20, 1984	West Berlin	stage 1
Jan. 7, 1985	West Berlin	stage 1
Jan. 8, 1985	northern Bavaria	pre-warning
Jan. 9, 1985	West Berlin	stage 1
Jan. 16, 1985	Kassel	stage 1
Jan. 17, 1985	Gießen	stage 1
	western Ruhr region	stage 2
	eastern Ruhr region	stage 1
Jan. 18, 1985	western Ruhr region	stage 3
	eastern Ruhr region	stage 2
	West Berlin	stage 1
Jan. 19, 1985	Giessen	stage 1
Jan. 21, 1985	Hamburg	pre-warning
	Hanover	pre-warning
	Bremen	pre-warning
Feb. 12, 1985	Hof	pre-warning
Feb. 13, 1985	Kassel and Gießen	pre-warning
February 1986	Hanau	pre-warning
February 1986	northern Bavaria (Hof, Wunsiedel)	pre-warning
February 1986	Nuremberg	pre-warning
February 1986	Brunswick, Wolfenbüttel	pre-warning
February 1986	Oker-Harlingerode	stage 1

Source: V. Prittwitz 1985 and newspapers (for 1986).

In this connection it might be interesting to note that the City of Nuremburg has tried to introduce stricter smog alarm standards for its area and has been heavily criticised for this by the Bavarian Government. This illustrates how difficult it is, in general, for local authorities to develop and implement more flexible approaches in response to local pollution problems and environmental needs.

Finally, FICA also authorises state governments to designate areas requiring special protection (e.g., spas, recreation areas, hospital zones). In such areas, stricter, preventative regulations for stationary emitting sources can be enforced. So far, no state government has passed ordinances for special protection areas.

3.2.3 Product-related measures

Product-related measures come very close to a preventative approach of air pollution control policy. In contrast to other, rather dominant, strategies they generally exclude follow-up problems caused by dilution/diffusion or end-of-pipe treatment. Furthermore, compared to other approaches used in the FRG's clean air policy, product-related measures have proved to be effective and efficient.

FICA provides that the federal government can legislate fuel standards in order to protect the environment from harmful effects of air pollution. On that basis, the federal government issued the Ordinance on sulphur content of light fuel oil and diesel fuel. Since 1979, the maximum level of sulphur compounds--calculated as sulphur--in light fuel oil (primarily used for domestic heating) and diesel oil may not exceed 0.3% by weight. The reduction of sulphur content was achieved in three steps:

- May 1975: 0.55%
- May 1976: 0.50%
- January 1979: 0.30%.

The regulation governing sulphur content has been one of the most effective in reducing SO₂ emissions and in improving ambient air quality, especially in urban agglomerations with many single heating furnaces. It is estimated that with the third step of sulphur reduction SO₂ emissions of 150,000 to 200,000 tonnes per year have been avoided. The Federal Minister of the Interior (responsible for environmental protection until June 1986) recently announced the intention to investigate the possibility of a further reduction in the sulphur content of fuels to 0.15% by weight. This would lead to a further reduction in SO₂ emissions of about 140,000 tonnes per year. The entailing price increases would be no more than 5% for light fuel oil.

In 1971, the Act for the reduction of air pollution from lead compounds in motor vehicle fuels was passed. The lead content of petrol fuels was reduced in two stages by this act to 0.15 g per litre, effective as of January 1976. As lead-free petrol is needed for three-way catalytic converters reducing NO_x emissions, in 1983 the federal government began preparing the legal ground for introducing unleaded petrol by January 1986. In January 1984, the petroleum industry in the FRG announced its readiness to supply unleaded petrol before 1986, in line with the trend in demand, and unleaded premium petrol from January 1986 onwards. To promote the sale of unleaded petrol the federal government has reduced the petrol tax as an interim measure. As of April 1, 1989, this tax reduction will no longer be offered to consumers. However, unleaded petrol is still selling rather weakly. According to a statement of the petroleum industry of March 1986, the market share of unleaded regular petrol is only 15 to 16% and of unleaded premium petrol about 3% (in the FRG premium petrol has a market share of 55%).

Since product standards are also a matter for decision by the EEC, its appropriate institutions had to be involved at this level. The EEC placed some restrictions on the plans of the federal government, as was the case for initiatives to strengthen standards for exhaust gas of motor vehicles.

FICA authorises the federal government to issue ordinances limiting or prohibiting the use of substances or products liable to cause toxic emissions, for example, through waste incineration. On the basis of this provision, the tenth ordinance for implementation of the FICA was enacted in 1978. It restricts marketing and use of products containing PCBs, PCTs and vinyl chloride aerosols.

3.2.4 Measures related to mobile sources

On the basis of FICA and the Road Traffic Act, the federal government can regulate by ordinance the design, equipment, operation and testing of motor vehicles. Several measures were taken to reduce motor vehicle emissions by amendments to the Road Traffic Licensing Order and by adopting directives of the EEC. However, all these measures failed, to a large extent, to meet the objective of the Federal Environmental Programme of 1971 to reduce motor vehicle emissions stepwise to one tenth of the 1969 average. In order to reduce emissions from motor vehicles more effectively, in 1983 the federal government decided to adopt the car exhaust standards used in the USA as of January 1986 and requested the EEC to take similar action.

After heated discussions, the EEC finally decided not to follow this request and proposed exhaust standards and time limits for their implementation much below those recommended by the German government. The EEC also raised concern about the FRG's plans to grant tax relief for the promotion of catalytic converters and the purchase of so-called low-pollution cars, but, in the end, this measure was accepted. Nevertheless, the fact remains that the EEC, authorised by the Treaty of Rome to set, inter alia, product and car exhaust standards binding for all member countries, massively hindered the FRG's efforts to reduce air pollution caused by car exhaust gas.

Table 8 lists the car exhaust standards agreed upon, in a compromise, by all EEC member states, except Denmark.

TABLE 8
CAR EXHAUST STANDARDS ADOPTED BY THE EEC

Vehicle category	Year of implementation	Emission standards (in g, yielded under standard testing)
A. greater than 2-litre engines	1988 for new models 1989 for new cars	CO: 25 HC + NO _x : 6.5 NO _x : 3.5
B. 1.4 to 2-litre engines	1991 for new models 1993 for new cars	CO: 30 HC + NO _x : 8
C. less than 1.4 litres		
Stage I	1990 for new models 1991 for new cars	CO: 45 HC + NO _x : 15 NO _x : 6
Stage II	Decision to be taken by 1987 at the latest on standards applicable in 1992 for new models 1993 for new cars	not yet determined

Denmark pursues an independent strategy in its attempt to establish stricter car exhaust standards. In July 1985, Denmark, Sweden, Norway, Finland, Switzerland, Austria, Canada and Liechtenstein signed a declaration to prepare as soon as possible national legislation on car emissions equivalent to the federal regulations in the United States. Thus, from a strictly formal point of view, the EEC directive is not effective as long as Denmark has not agreed to it.

The EEC has started negotiations about stricter emissions standards for trucks and buses--a very urgent issue since these vehicles have a considerable share in air pollution. In the FRG, for example, they are responsible for one third of NO_x emissions, 13% of HC emission, two thirds of SO₂ emissions and three quarters of soot and particle emissions resulting from traffic. German truck makers have meanwhile voluntarily agreed to reduce NO_x emissions by 20% of the legal standard as of January 1986. Critics have pointed out that this voluntary commitment will have no significant impact since a good deal of the trucks now in use already emit less NO_x. So far, there is no indication that the EEC will act as a "pacemaker" and carry through emission limits based on the best technology available as proposed in the United States.

The federal government had initiated investigations to determine the pollution abatement effects of a general speed limit on motorways (Autobahnen). The results were made public in November 1985. Although a final report had not been available, the government reacted with unusual promptness and decided not to impose a speed limit 100 kilometres per hour (62 miles per hour) since such a measure would not lead to a significant decrease of nitrogen oxide emissions. The Technical Control Board (TÜV) Rhineland-Palatinate who had undertaken the study, concluded that NO_x emissions would be reduced by only some 32,000 tonnes per year. Both the government's decision and the research methods were attacked from many sides, e.g., environmental organisations, forest owner associations, the Green Party and some state governments. An independent research institute at Heidelberg (Institut für Energie- und Umweltforschung = IFEU) reported that the reduction rate would be much higher if "some unrealistic assumptions or mistakes" of the Board's study were eliminated and, especially, if the speed limit on motorways would be combined with a reduction of the present speed limit on state highways from 100 km/h to 80 km/h. The IFEU study calculated that NO_x reduction would be in a range of 170,000 to 210,000 tonnes

per year--a result very similar to that published by the Federal Environment Agency in 1984. Many observers interpreted the government's decision not to impose a general speed limit on motorways as a victory for the automobile lobby in West Germany. The auto industry preferred stricter emission standards over an imposed speed limit for reasons of international competition. It saw an advantage in maintaining the reputation of German cars as being particularly safe even at high speeds.

3.2.5 General supplementary and supporting measures

The federal government, the states, local authorities and other institutions, in manifold ways, provide for financial support and other incentives to promote research and development as well as pollution abatement technologies and other related activities to reduce emissions and improve air quality, developing methods for identifying damage as well as its causes, etc.

Since 1975, provisions for tax write-off have granted higher annual depreciation rates for pollution abatement investments than for other production facilities. In 1984, special tax write-offs on the basis of Article 7d of the Income Tax Law were granted for a total investment of 3.589 billion DM. The major part of this sum was invested in air pollution control. From 1975 to 1984, investments in that sector increased by seventeen times (1975: 137 million DM; 1985: 2.244 billion DM). Article 7d also allows for faster depreciation: 60% in the first year and 10% in each of the subsequent four years. Experts have pointed out, however, that the provisions under Article 7d have one major disadvantage. They apply only to end-of-pipe technologies and not to integrated "clean" technologies. Therefore, these provisions have had only minor impacts on environment-oriented innovation in production and products. The "Conference of federal and state ministers for the environment" has demanded appropriate modification of the Income Tax Law, but as of March 1986 no decision has been made.

Mio. DM

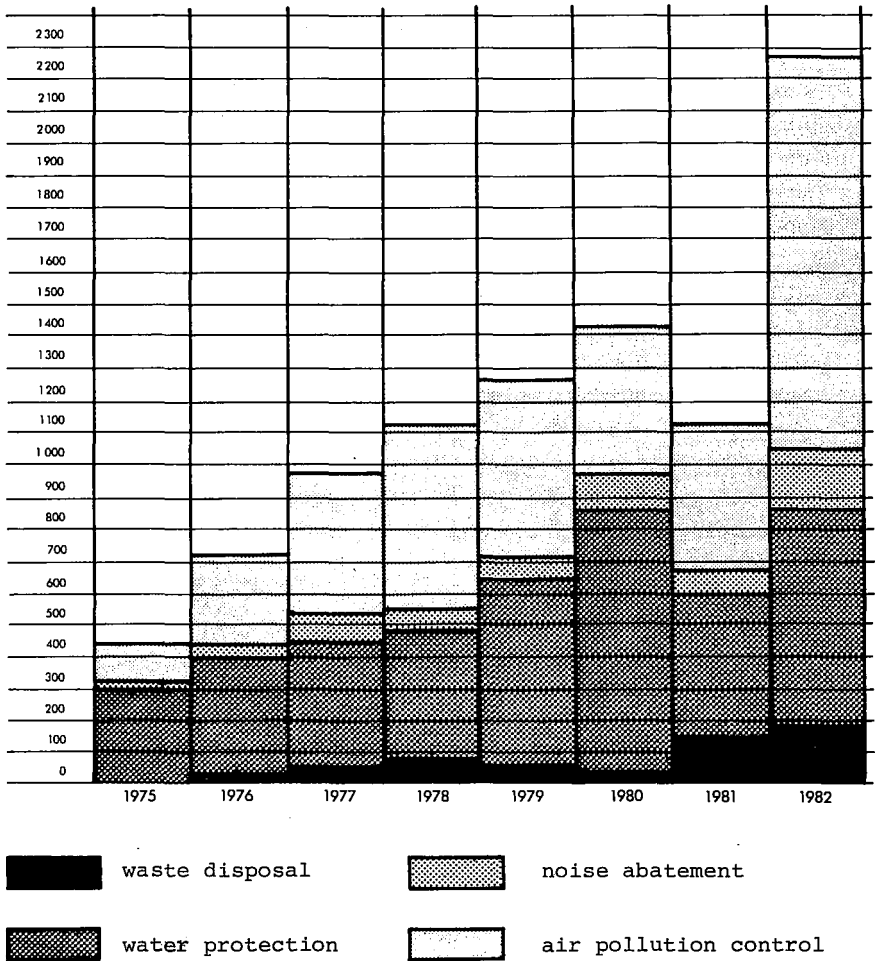


Figure 11. Pollution control investments for which favourable depreciation rates were granted (source: Umweltbundesamt 1984).

The "European Recovery Programme" grants low interest loans for environmental protection measures including the construction of pollution abatement facilities and other investments in air pollution control. The volume of credit has been increased by 600 million DM for each 1986 and 1987. In 1986,

for example, a total credit volume of 1.2 billion DM is at disposal. Furthermore, credits and bonds for air pollution control measures are granted by the states and by the Reconstruction Loan Corporation (Kreditanstalt für Wiederaufbau). In 1979, the federal government initiated a programme for the modernisation of old emitting plants (Altanlagen-sanierungsprogramm) providing financial support for the exemplary improvement of such facilities. The programme has a total of 560 million DM at its disposal and runs until 1987. To obtain financial support, plant operators must demonstrate that they are contributing towards reducing the amount of gaseous or dust emissions. More than a quarter of the programme's funds is invested in measures directly or indirectly reducing SO₂ emissions. A further objective of the programme is to gather information on technical possibilities for pollution abatement measures in existing sources and for setting emission standards. Until 1983, 171 projects were supported with altogether 398 million DM (see fig. 12).

The federal government has taken several measures to promote the purchase of so-called low pollution cars and lead-free petrol as well as the installation of catalytic converters in old cars. As of April 1, 1985, tax on lead-free petrol was reduced by 0.02 DM. A further tax reduction by 0.03 DM came into effect on January 1, 1986. Since July 1985, owners of low pollution cars pay considerable less automobile taxes. Correspondingly, taxes for cars not meeting the requirements for a low-pollution certificate have been increased as of January 1986. Car owners making use of tax benefits offered can obtain maximum tax savings of 2,200 DM over a period of seven years. The amount of tax savings depends on the extent to which cars comply with the EEC emission standards. According to a report of the Federal Agency for Car Traffic (Kraftfahrbundesamt), until January 1, 1986, 636,000 cars have received a low-pollution certificate. 161,400 of these meet the strict US emission standards, 323,000 cars (including 321,700 cars with diesel engines) comply with the EEC standards. The remaining 151,000 cars are certified as "relatively low polluting".

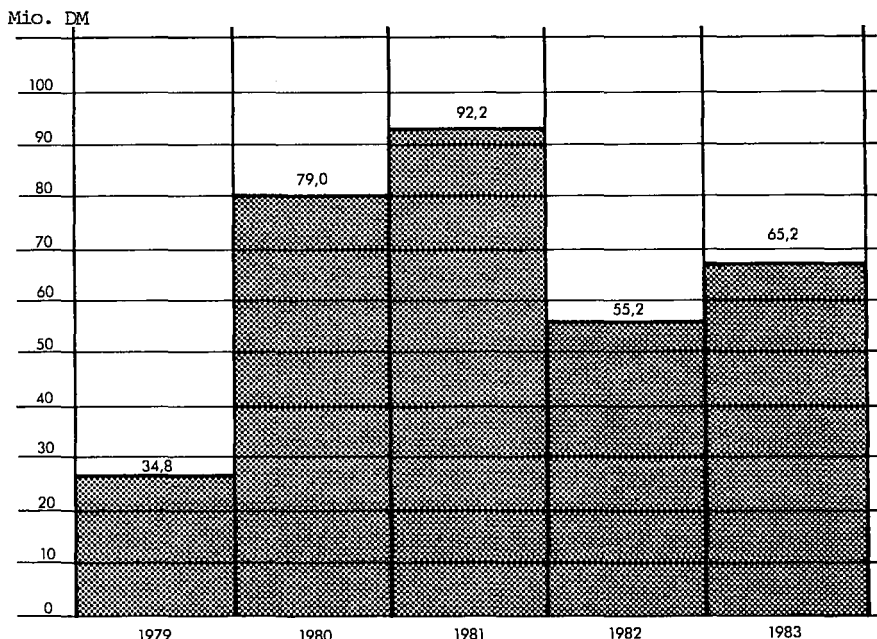


Fig. 12. Annual allowances by the federal government for air pollution control investments in connection with the Programme for the Modernisation of Old Emitting Plants (source: Umweltbundesamt 1984).

Since the beginning of 1982, about 75 research projects have been commissioned by several federal ministries to investigate the problem of "dying forests" (Waldsterben). (The official term for this phenomenon is "new type of forest damage".) In total, about 70 million DM have been made available by the federal and state governments and other institutions for this research.

Several energy-related measures directly or indirectly reducing emissions have also been introduced or supported by the federal and state governments. The federal government enacted legislation related to energy saving and the rational use of energy and corresponding financial support. For example, the revision of the 1977 ordinance on thermal

insulation of 1982 successively introduced new requirements for thermal insulation of new buildings; the Modernisation and Energy Saving Act provided subsidies for energy saving measures in housing construction between 1978 and 1982. Since 1983, special depreciation rates are granted for solar heating units, heat recycling systems, wind power and biogas units, etc. The development of district heating systems is supported with several federal and state-funded programmes. Nevertheless, support for the development and marketing of low-polluting energy systems has been limited, except for strong governmental support of R&D in nuclear energy which many do not consider to be an environmentally sound energy source at all.

Finally, reference must be made to the promotion of international cooperation in doing research and exchanging information on air pollution problems as is done for several subjects and in cooperation with numerous states and organisations (e.g., ECE, EEC, OECD, UN, WHO). Fortunately, the FRG has succeeded in recent years to exchange scientific, technical and other information on air pollution problems with eastern European countries, too. Considering the quite active "exchange of air pollutants" with these countries, this development must be all the more welcomed. On the FRG's initiative a "Multi-lateral Conference on the Environment" was held in Munich, in June 1984, which focussed on air pollution problems and possible measures to combat air pollution.

As already mentioned, for most air pollution matters the power for implementation and enforcement rests with the state governments. According to the specific situation, the individual state governments set different priorities in selecting the most urgent air pollution problems and the approaches to deal with them. Consequently, there is a great variety in the combination of available approaches. In addition to these approaches, and combinations thereof, based on national legislation or state legislation derived

therefrom, there are also various instruments and approaches not based on legislation. In most cases, these are special measures and programmes, sometimes combined with financial support, which have been developed in order to prevent a further increase of air pollutants harmful to forests. For example, the governments of North Rhine-Westphalia, Bavaria and Baden-Wuerttemberg have made what may be called "pollution control agreements" with power plant operators to reduce SO_2 , and partly also NO_2 , emissions within a certain time period and to an extent not prescribed by law. Recently, local authorities, especially larger municipalities, have also started to develop their own strategies to improve air pollution control measures by public and private firms. However, as their competences in air pollution control are rather limited, local authorities are mostly confined to using their general political influence or trying to utilize legal competences from other laws, such as land use and building laws. As yet, it is not possible to make a general statement concerning the influence and importance of these developments because a more active and positive involvement of local authorities in air pollution control has just begun. Nevertheless, the measures taken hitherto seem rather promising.

IV DEVELOPMENTS IN AIR POLLUTION ABATEMENT TECHNOLOGY AND RELATED EXPENDITURES

Environmental programmes and public pressure, mainly resulting from the problems of dying forests and public health, have not failed to influence industry in one way or the other. In some cases, industrial innovation was stimulated. In other cases, because of the legal requirement to select the best technology available and because of high costs innovation and retrofitting of old facilities was discouraged. Due to weak supra-national EEC legislation over many years, the construction of low-pollution cars was decisively impeded. Thus, expenditures for research and development, and for investments in new product lines for low-pollution cars has started only recently.

Investments in air pollution control for stationary sources has a much longer history. As most of the emissions from stationary sources result from combustion processes, the following review of abatement technologies will focus on this aspect. Combustion of fuels for energy production is a major cause of air pollution problems, therefore, energy saving measures are of particular interest. In the industrial sector, for example, with improved production processes, the introduction of heat and power cogeneration, waste heat recovery and waste material recycling, etc. industry's share in the final energy consumption could be lowered from 48% in 1960 to about 34% in 1980. The specific industrial fuel consumption related to net production was halved within this period.

The discharge of pollutants, such as carbon monoxide, unburnt hydrocarbons and soot, can be reduced considerably by improving combustion processes. Techniques effecting low CO, HC and soot emissions have been developed mainly because they contribute to an efficient use of energy and, thus, save money. The development and introduction of combustion methods with low nitrogen oxides emissions has been rather slow. Fluidised bed combustion, a special method to achieve low

NO_x emission levels, is, as yet, rarely applied, but there seems to be an uptrend in this technology. As of March 1986, only two flue gas denitrification plants are operated on a large scale in the FRG. However, as a result of the Ordinance on Large Combustion Plants of 1983 and several state government programmes, this pollution abatement technology (mainly the selective catalytic reduction method) will have to be installed in new and old large combustion plants, especially power plants, in the coming years. The first large coal-fired power plant equipped with selective catalytic reduction was built in Altbach (Baden-Wuerttemberg) and started operation in December 1985. The investment costs for this denitrification plant were approximately 65 million DM, a quarter of which was paid by the federal government. It is expected that the retrofitting of large combustion plants with flue gas denitrification facilities will be completed by 1990. According to an estimate by the Federal Environment Agency, NO_x emissions from power plants will be reduced in the time period 1980 - 1995 from 1 million tonnes to 0.3 million tonnes. As of March 1986, 60 pilot plants for denitrification are under construction or in operation.

Flue gas desulphurisation is an effective means to reduce SO₂ emissions. With the currently available technology, desulphurisation rates of up to approximately 95% are achievable. At the end of 1983, ten power stations in the FRG were fitted with flue gas desulphurisation facilities with a total capacity of 3,400 MW(el). For coal-fired power plants with a capacity of 150 MW(el), investment costs for this technology are about 40 million DM; for power plants with a capacity of 750 MW(el) about 125 million DM. (Flue gas denitrification facilities are not half as expensive as desulphurisation plants.) It is expected that the Ordinance on Large Combustion Plants of 1983 and related programmes of several state governments will entail a large increase in flue gas desulphurisation facilities in old and new large combustion plants until 1993. According to official estimates, the total SO₂ emission in the FRG will then be

reduced by 50% compared to 1980, and the total desulphurisation capacity will then amount to more than 50,000 MW(el).

The first large coal-fired power plant (770 MW(el)) equipped with flue gas desulphurisation started operation in 1977 at Wilhelmshaven, Lower Saxony. At first, flue gas desulphurisation was practised only partially, but later on, the technology was extended stepwise to all blocks of the power plant. Since 1985, its total flue gas is desulphurised at a minimum rate of 90%. As a result, SO₂ emissions are significantly lower than prescribed by the Ordinance on Large Combustion Plants of 1983, namely 400 mg/m³. Through the use of imported low-sulphur coal, SO₂ emissions could be further reduced and are now at an average of 200 mg/m³. The total investment costs for this power plant were 660 million DM including 110 million DM for the desulphurisation equipment. Table 9 lists those West German coal-fired power plants with a capacity of more than 300 MW(el) already using flue gas desulphurisation or going to use it before 1988.

Increasing investments in desulphurisation plants will certainly help reduce SO₂ emissions, but in the long run, this end-of-pipe technology will lead to new environmental problems because of the large amount of gypsum it produces. This feature of shifting a problem from one environmental medium to another is what I call medial problem dislocation. Air pollution is reduced at the expense of an eventually increased soil and ground water pollution. It is already anticipated that it will be very difficult to market, or to safely dispose of, the enormous amount of gypsum which will be produced when most of the planned desulphurisation plants will be in operation. Gypsum is the end product of about 90% of West German desulphurisation plants. In 1983, about 75,000 tonnes of gypsum were produced; in 1984, the amount was almost the double, about 130,000 tonnes, and for 1985 the preliminary figure is 200,000 tonnes of gypsum. It is estimated that in the 1990s about 3.9 million tonnes will be produced annually. Furthermore, it is still unclear how the

TABLE 9

COAL-FIRED POWER PLANTS WITH A CAPACITY OF MORE THAN 300 MW(el) FITTED WITH FLUE GAS DESULPHURISATION IN THE FRG (INCLUDING THOSE TO BE PUT IN OPERATION BEFORE 1988)

Owner/Power plant	Capacity/Fuel	End product
NWK, Wilhelmshaven	750 MW(el), StKo ¹⁾	gypsum sludge/ gypsum
Isar-Amperwerke, Zolling Block 5	450 MW(el), StKo	gypsum
BKB, Buschhaus	350 MW(el), BrKo ²⁾	sulphur
Preussenelektra, Mehrum	700 MW(el), StKo	gypsum
EVS, Heilbronn, Block 7	720 MW(el), StKo	gypsum
STEAG, Lünen	350 MW(el), StKo	gypsum
STEAG, Voerde, West	2 x 350 MW(el), StKo	gypsum
STEAG, Walsum	410 MW(el), StKo	gypsum
RWE, Weisweiler	2 x 600 MW(el), BrKo	gypsum
BASF, KW Mitte, Ludwigshafen	700 MW(el), StKo	liquefied SO ₂
RWE, Goldenbergwerk	2 x 600 MW(el), BrKo	gypsum
Badenwerk, Karlsruhe Rheinh.-DKW, Block 7	540 MW(el), StKo	gypsum
Neckarwerke, Altbach-Deizisau, Block 5	420 MW(el), StKo	gypsum
RWE Grewenbroich Neurath, Blocks D + E	1200MW(el), BrKo	gypsum with 10% residual moisture
Großkraftwerk Franken, Erlangen, Franken II	700 MW(el), StKo	gypsum
Saarbergwerke, Weiher III	707 MW(el), StKo	gypsum
Saarbergwerke/Bayernwerke/Badenwerk/EVS, Bexbach	750 MW(el), StKo	gypsum
Saarbergwerke/Bayernwerke/Badenwerk/EVS, Bexbach	750 MW(el), StKo	gypsum
Preussenelektra, Heyden IV	800 MW(el), StKo	gypsum
RWE, Neurath, Block F	600 MW(el), BrKo	gypsum
RWE, Neurath, Block G	600 MW(el), BrKo	gypsum
STEAG, Bergkamen A	747 MW(el), StKo	gypsum
VEW, Werne	750 MW(el), StKo/gas	gypsum
STEAG, Voerde A	707 MW(el), StKo	gypsum
STEAG, Voerde B	707 MW(el), StKo	gypsum
VKR, Scholven F	740 MW(el), StKo	gypsum
VKR, Knepper C	370 MW(el), StKo	gypsum
VKR, Scholven, Blocks B, C, D, E	4 x 370 MW(el), StKo	gypsum
RWE/Preussag, Ibbenbüren	770 MW(el), StKo	gypsum
Großkraftwerk Mannheim, GKM Block 7	475 MW(el), StKo	ammonium sulphate
Großkraftwerk Mannheim, GKM Blocks 14 + 15	440 MW(el), StKo	salt peter of ammonium sulphate

1) StKo = hard coal

2) BrKo = lignite

Source: Büro für Publizistik (ed.), Aktiver Umweltschutz in der Bundesrepublik Deutschland, 1985.

waste will be managed which has accumulated in the catalytic converters used in denitrification plants, no matter if entire converters will have to be replaced or not.

Statistics on environmental protection expenditures in industry show that about 50% of all pollution control investments are spent on air pollution control facilities. According to experience, the operating costs per annum amount to about one-third of the investment costs during the depreciation period of the facility. About two-thirds of all industrial investments in air pollution control were made in the following four sectors: power-generating industry, petroleum industry, iron and steel industry, chemical industry.

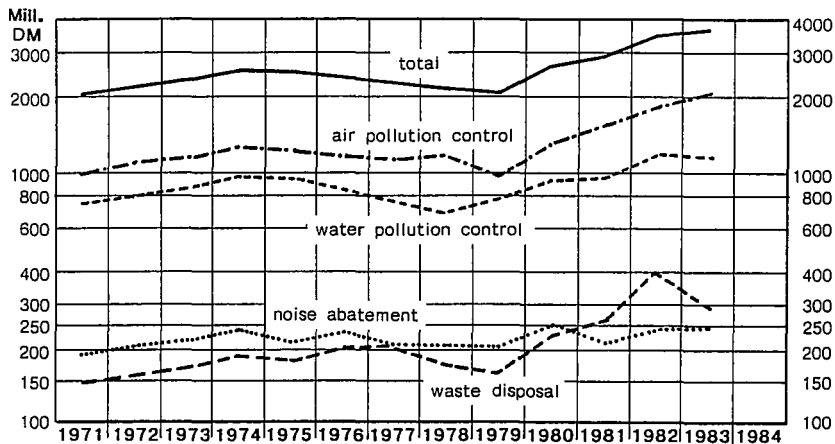
According to studies by ifo-Institut (Munich), a significant uptrend of so-called eco-industries started in 1971 with the beginning of a systematic environmental policy. The following figures shall illustrate the development of this industrial sector. In 1971, local authorities (Gebietskörperschaften) had spent 5.7 billion DM for environmental protection and related measures; in 1983, the total amount was 2.3 times as much: about 13 billion DM. A similar development had taken place in the business sector. During the same period, expenditures for environmental protection and related measures had doubled. In 1983, the total expenditure was 6.9 billion DM. In that same year, local authorities and private enterprise together spent 20 billion DM for environmental protection measures, which equals 1.2% of GNP. For actual anti-pollution investments, the business sector spent 4 billion DM in 1983, almost half of which was used for air pollution control equipment. (Corresponding figures for the public sector are not available.)

In its study on the eco-industrial market, ifo-Institut ascertained that the greatest demand is for so-called add-on (or: end-of-pipe) technologies, while so-called integrated or clean technologies play only a minor role. This result has been confirmed by a similar study of IIES/Science Center

Berlin (see table 11). It is particularly interesting that the development of the eco-industrial market was primarily stimulated by public (governmental) incentives, subsidies and legal requirements for environmental protection.

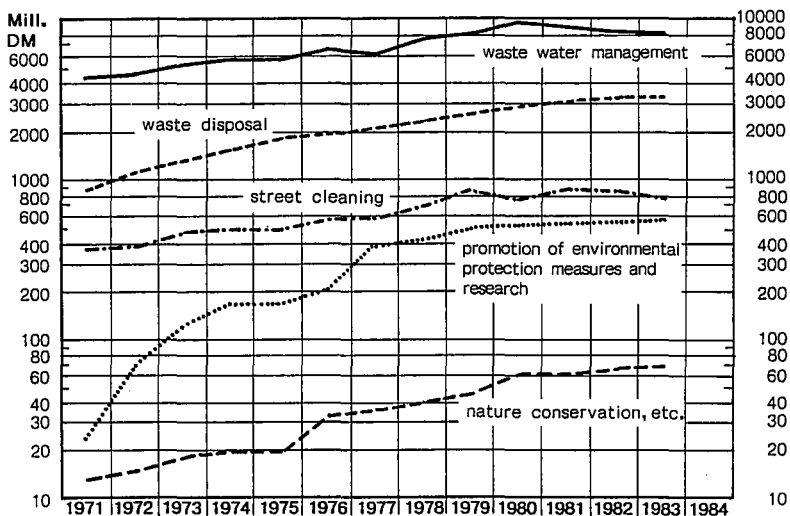
Finally, it should be mentioned that the so-called eco-industry (production of pollution control equipment, monitoring appliances, etc.) has gained increasing importance for employment and the general economy. Today, there are about 1,200 firms in the FRG offering environmental protection technologies. Most companies supplying the eco-industrial market are small and medium-sized. They are especially competitive in this sector because of their flexibility and innovative potential. Ifo-Institut estimated that in 1983 about 170,000 persons were employed in the eco-industrial sector (including construction work); 90,000 persons were working for outside suppliers. In 1985, the Federal Ministry of the Interior estimated that implementation of the Ordinance on Large Combustion Plants will create about 47,000 new jobs. The new legal requirements for low-pollution cars will create about 14,000 jobs.

The eco-industry is one of the rare sectors with rather high growth rates (averaging 14% per year since the end of the 1970s). In addition, in 1979 the federal government introduced a special job-creation programme with explicit environmental measures. The state of Hesse started such a programme in 1983. Both programmes are only indirectly and insignificantly related to air pollution control, for example through traffic improvement or energy-saving measures. It is, however, expected that the new legal requirements in the area of air pollution control, such as the stricter emission levels for small and medium-sized firms as prescribed in the new TI Air of 1986 (part 3), will stimulate investments in air pollution control equipment (desulphurisation, denitrification, etc.) of about 28 to 32 billion DM until the beginning of the 1990s. The following figures and tables provide an overview of expenditures for environmental protection measures by the private and public sectors.



Note: left scale: million DM, right scale: enterprises with 20 and more employees

Figure 13. Investments of the private sector in environmental protection, 1971-1983 (source: R.-U. Sprengler, Munich: ifo-Institut, 1985).



Note: public sector = federal and state governments, local authorities; left and right scales: million DM

Figure 14. Environmental protection expenditures by the public sector, 1971-1984 (source: R.-U. Sprengler, Munich: ifo-Institut, 1985).

TABLE 10
AIR POLLUTION CONTROL INVESTMENTS BY PRIVATE ENTERPRISES

Year Invest- ments	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	'71-'83
in million DM	990	1071	1139	1242	1242	1154	1120	1128	964.5	1291.8	1531.4	1810.7	2071.2	16729
in % of total environmental protection investments	48	48	48	48	48.3	48.2	49.2	51.6	46	48.3	51.9	50.5	55.8	49.7

Note: private enterprises with 20 and more employees

Source: R.-U. Sprenger, ifo-Institut München, 1985.

TABLE 11
 POLLUTION CONTROL INVESTMENTS IN MILLION DM, 1975-1981, BY SOURCES AND MEANS

Year	WATER:	end of pipe	inter-grated	product-related	AIR:	end of pipe	inter-grated	product-related
1975	911	727	180	5	1,213	764	205	244
1976	821	673	140	7	1,154	858	240	56
1977	749	595	144	10	1,120	771	210	140
1978	686	534	141	9	1,129	725	223	180
1979	773	678	85	10	965	686	231	47
1980	915	770	138	6	1,292	873	385	34
1981	951	817	124	10	1,531	1,127	351	53

Year	WASTE:	end of pipe	inter-grated	product-related	NOISE:	end of pipe	inter-grated	product-related
1975	178	146	30	1.7	210	134	71	5
1976	199	171	27	1	223	144	69	10
1977	203	146	52	5	207	138	61	8
1978	172	139	32	1.6	201	129	62	10
1979	160	136	22	1	201	123	68	10
1980	220	186	33	2	247	152	80	16
1981	256	217	35	4	210	131	73	5

Source: K. Zimmermann, Präventive Umweltpolitik und technologische Anpassung, IIUG dp 85-9, Berlin 1985.

V ALTERNATIVE AIR POLLUTION CONTROL STRATEGIES AND INSTRUMENTS

In view of the apparent shortcomings of environmental policies and the need for immediately effective measures to cope with the problem of dying forests, over the last few years increasing consideration has been given to alternative approaches to air pollution control in the FRG. One of the most intensively discussed proposals is to adopt market-type economic incentives as part of environmental control programmes. Proponents of such schemes claim that these will improve both the effectiveness and the efficiency of air pollution control policy.

Before evaluating alternative strategies available to date, the basic reasons for the shortcomings of West Germany's clean air policy prior to its changes in 1983 will be briefly explained. Only the most important factors will be reviewed, primarily based on my experience with an international comparative study on air pollution control policies for stationary sources conducted by the International Institute for Environment and Society of the Science Center Berlin (Luftreinhaltepolitik im internationalen Vergleich, 6 volumes, Berlin 1985).

1. Shortcomings of West German Clean Air Policy Before 1983

Although the legal framework of air pollution control in the FRG--compared to the international average--is one of the most comprehensive legislations, it has some major gaps and shortcomings which are responsible for corresponding problems in implementation. As already mentioned, some substantial improvements in the legal requirements have been made since 1983. (Their potential effects have been discussed in the preceding sections.)

- (1) The objectives of air pollution control policy are not clearly stated. A political strategy aiming at the prevention of further deterioration of environmental quality and a clean-up of polluted areas can only to a

limited extent rely on ambient air quality standards because these are mainly enforceable when permits for new large installations are to be granted. Compared to the state of scientific knowledge and to proposals by the World Health Organisation, West German ambient air quality standards are rather weak, in particular the standard for SO₂. Furthermore, the process of standard formulation is not a purely scientific one. It is heavily influenced by industrial and other interest groups and by the way in which information is selected and the procedure is structured. Environmental interest groups are almost excluded from the process of standard setting. Consequently, standards are more a political convention than the result of scientific considerations. Moreover, the factual significance of an ambient air quality standard heavily depends on the supplementary monitoring requirements. Studies have revealed that the control function of a standard for enforcement practice is considerably influenced by the requirements for means surrounding the standards, such as measuring systems, monitoring areas, methods of analysis, time periods and statistical methods to be applied. It became evident that with these means a standard could be lowered or tightened. Industry-related groups and experts have many more opportunities to influence the requirements surrounding a standard than the public which has only limited means to assess the importance of such highly technical and complex regulations. Similar patterns appear in the process of formulating emission standards which serve as concretisations of the "state of technology". Investigations support the assumption that "programme deficits" taking the edge off enforcement instruments of the programme, in many cases, are the result of the influence of industrial interests. Since air pollution control policy in the FRG tends to become increasingly complex and detailed in legal and technical terms, the substantive meaning of air pollution control regulations is increasingly harder to assess and the whole policy area becomes more unclear to the public.

- (2) The implementation of a comprehensive air pollution control policy is a relatively new task compared to other policy areas, such as energy, industrial, and agricultural policy. Air pollution control authorities and the respective departments at the governmental level usually lack a power structure comparable to that of the older policy sectors. As air pollution control measures usually interfere with the objectives and interests of other policy sectors, conflicts between them arise quite frequently. Due to the prevailing power structure environmental concerns tend to be weakened. In addition, the traditional power structure largely prevents an effective administrative link between the causal, inter-related policy areas, which would be highly necessary for an effective and rational air pollution control policy. As things stood until recently, energy policy, for example, could be pursued almost independently on the basis of its own premises, with little thought to its impacts on environmental objectives. When considering new approaches to air pollution control, it is most important to consider these political constraints in order to achieve realistic strategies.
- (3) Installations licensed before 1974 are responsible for most of the emissions of major pollutants. An effect-oriented control policy should have concentrated upon these sources. However, the legal provisions have not led to the establishment of demanding control requirements. The clause in Article 17 of FICA that abatement orders are only justified if the authority can demonstrate the availability of abatement technologies and the economic feasibility prevented improvement orders almost completely. (In 1985, FICA was amended to facilitate clean-up orders.) Furthermore, agencies in charge of pollution control often lack sufficient information on technological and economic possibilities. This is not the only reason why legal provisions for abatement orders were doomed to fail. Economists, above all, have pointed at the structural deficiency of the system: the

lack of incentives for emitters to reduce their emissions. Given the case that an emitter voluntarily raises the standard of anti-pollution technology, there are no rewards for his doing so. Instead, he may even have some disadvantages if through his initiative the state of technology would be advanced and made obligatory for all other comparable plants. If he runs several plants, it may then occur that the authorities force him to equip all of them with the same technology before he is ready to do so. The structural deficit of air pollution control policy can be described as follows: the roles of environmental protection agencies and the business sector have been irrationally reversed. The agencies have to promote technological progress, while under existing conditions it is rational for the business sector to aim at no technological progress in air pollution control.

- (4) One of the basic objectives of air pollution control regulations and programmes, the precautionary (prevention) principle to prevent emissions harmful to human beings and the environment, has evidently not been successfully implemented. The main reasons for this failure was the inability of federal and state governments to enforce a comprehensive energy saving policy and stricter emission standards and exhaust limits for stationary and mobile sources, and the preference for the so-called strategy of high chimneys. In general, the responsible authorities relied much more on strategies for the dispersion of pollutants than on enforcing pollution abatement equipment.
- (5) Enormous amounts of money have been spent on monitoring equipment. However, reliable and comprehensive data on damages, emissions and the ambient air quality situation are still lacking. Reliable and valid monitoring data are not only a precondition for the development of rational pollution control programmes but also an important means for the general public to evaluate the achievements in air pollution control of responsible authorities. In general, the means for keeping the

public informed about environmental issues and programmes are still in their infancy, especially when it comes to the "hard facts". Even the public authorities responsible for developing air pollution control programmes or implementing them lack fundamental data on industrial emissions. Whenever data were available it was often the case that certain authorities used them exclusively, without making them accessible to other authorities. Only very few large emitters monitor their emissions continuously, and there is no provision for a direct and continuous transfer of such emission data (e.g., telemeter systems) to the responsible agencies.

- (6) From the 1970s on, the general public in the FRG and, in particular, citizens' initiatives, have become increasingly aware of air pollution problems and gained amazing knowledge of the technical, legal, economic, and ecological conditions--even if these were very complex and detailed. Yet, although the basic preconditions for a responsible participation were given, environmental protection groups were allowed only limited involvement in environmental policy decisions. In cases where the inclusion of members of the affected public or environmental interest groups has been institutionalised (especially in the area of permit issuing to designated facilities), it often has turned out that no substantial participation of these groups is possible due to the close cooperative and informal relationships between the responsible agency and emitters outside the formal decision-making process. Thus, emitters have much better possibilities to influence air pollution control policy according to their interests than the public or environmental interest groups. This biased structure of participation did not only lead to poor decisions on air pollution control, but also stimulated and, in a certain respect, justified opposition to formally correct decision by other means (e.g., blockades, demonstrations). In general, substantial cooperation (or even a certain kind of coalition) of public authorities with concerned

citizens or environmental interest groups was, until recently, a rare feature in the FRG.

- (7) Citizens harmed by air pollution and environmental interest groups have only very limited possibilities to influence government policy and emitters' behaviour or to seek remedy for damage through court action. The strict requirements for court action and other legal constraints often preclude citizens or environmental organisations taking their courses to court. In the event of actual or potential damage, the burden of proof lies with the injured party who must not only have evidence for a clear cause-and-effect relationship but also for the particular pollution source responsible for this. In complex cases, such as damage caused by air pollution, it is almost impossible to fulfill these requirements. Thus, even in the present situation where forest owners suffer tremendous economic losses through air pollution, the prospects for getting compensation through court action are very limited. All lawsuits filed against the federal government for damage to forests by cities or private persons were rejected in the district courts. As of March 1986, appeals filed with the higher courts at the next level had yet to be decided. The plaintiffs accused the federal government of neither setting nor enforcing legal requirements sufficiently to control air pollution, so that damage to human health and forests could have been avoided. All in all, one may say without exaggerating that the existing legal principles are much more in favour of those polluting the air than those suffering damage from air pollution.

2. Alternatives

Based on the findings of several studies on the shortcomings of present air pollution control policies, some strategies, instruments, and technologies are described in the following which may contribute to a better performance in air pollution control.

With respect to control technologies, almost all technologies already available at a practical level are applied, or will be applied in the near future, to prevent or reduce the release of air pollutants. Just to name a few: desulphurisation of coal and oil, staged combustion processes, limestone injection multi-stage burning, fluidised bed combustion, flue gas desulphurisation and denitrification, dust collectors, and catalytic converters for automobile exhaust control. Especially fitting and retrofitting of larger furnaces with flue gas desulphurisation and denitrification equipment will increase substantially within the next ten years. Some experts have pointed out that this development may entail a certain increase in electricity rates. This opinion, however, is not commonly shared; and it is not likely that any significant distortions of the international competitiveness of German industries will occur. More concern should be given to the fact that, in spite of the wide range of available pollution abatement technologies, end-of-pipe treatment still prevails. It is well known that end-of-pipe technologies are not the optimal solution because, in the long run, they can pose new problems, e.g., the disposal of end and by-products such as gypsum from flue gas desulphurisation. To overcome such potential problems, preference should be given to other technologies and approaches. Especially energy efficiency in industry and households should be improved and structural changes away from energy-intensive industries should be promoted. Many studies have shown that energy conservation is the best approach, both in environmental and economic terms, to solving major air pollution problems. This would also provide a sound basis for safeguarding the future of the domestic coal-mining industry. However, at present, energy saving measures play only a minor part in governmental air pollution control strategies. The reasons for this may be manifold, but there is growing evidence that it is primarily the strong position of the West German power supply industry which, so far, has prevented approaches emphasizing energy saving and efficiency. The energy supply market in the FRG is highly centralized and monopolistic:

only nine big companies generate almost 90% of the total public electricity supply. The legal basis responsible for the powerful position of just a few energy supply companies is the "Law for Promotion of the Energy Supply Industry" (Gesetz zur Förderung der Energiewirtschaft) of 1935 which was enacted to cut out competition in this sector. This law has survived basically unchanged. Critics have pointed out that the present structure of energy supply with large central power plants is too inflexible and inefficient. In a decentralised system a greater number of small power plants located closer to consumers would not only increase energy efficiency but also permit utilisation of waste heat (co-generation plants). Moreover, increased energy efficiency, which ultimately means a better ratio between primary energy input and energy output, would contribute to reductions in emissions. It would, therefore, be helpful to have emission standards referring to final energy output, thus both enforcing an efficient use of resources and cutting down air pollution. Appropriate technological alternatives to large conventional power plants have been available for quite some time, such as small-scale thermo-electric stations for residential blocks or fluidised bed combustion, a technology particularly well-suited for small power plants, which does not only reduce SO₂ emissions but also NO_x, dust, etc. emissions.

A short time ago, some local governments took the initiative to develop decentralised, low-pollution, and resource-saving energy supply systems. The best known example is that of the city of Flensburg where district heating and cogeneration of heat and electricity are practised. Meanwhile, the federal government has also become interested in the matter. The ministries of construction, and research and technology have funded a 20 million DM research project for the development of local energy concepts. It should also be mentioned that the government of Hesse (a coalition of Social Democrats and the Green Party) actively supports structural changes in energy policy towards a decentralised,

environmentally more sound, and more efficient energy supply system.

Surplus energy obtained in small and medium-sized industrial and local power plants could be much better utilised if the large power companies were more willing to buy it and to pay fairer prices for it. As yet, the energy supply industry pays only the equivalent of fuel saved and not the equivalent of total costs saved (including fuel, investment, and operational costs) as is stipulated under Article 210 of the US "Public Utility Regulatory Policies Act" (PURPA of 1978) for electricity produced by cogeneration plants or renewable energy sources. More attractive prices for private and local suppliers would create a further incentive for decentralised energy systems and reducing waste of energy.

As already mentioned, realistic concepts for an environmentally more sound and emission-reducing energy policy and appropriate technologies are already available. Therefore, it is now basically a matter of politics to implement new energy concepts. First of all, it would be necessary to overcome the powerful position of the energy supply industry which is very hostile against losing control over energy policy planning. This would be the basic prerequisite for any rational approach to improving air pollution control policy by re-directing energy policy to an "environmentally sound path". In view of the fact that the West German power industry is one of the most influential interest groups with strong lobbies at all levels of government, the prospects for successful and rapid changes are, however, rather gloomy.

In the area of automobile exhaust it has turned out that the legal requirements for so-called low-pollution cars and the introduction of catalytic converters cannot basically solve air pollution problems caused by traffic. Thus, the alternative would be to promote the development of cars with higher fuel efficiency and cars using clean fuels such as liquefied gas. Furthermore, priority should be given to improving the

public transport system accompanied by restrictions on private traffic. However, such approaches would probably be met with the strong opposition of the automobile industry.

With respect to monitoring and reporting, the present system needs basic improvement to meet the demand for more reliable information on emissions, ambient air quality and damage to the environment. Again, there is not a lack in appropriate technologies. On the one hand, emitters are opposed to have their activities made more transparent, and, on the other hand, responsible authorities are still quite unwilling to provide the public with information which puts citizens in a position to evaluate the actual performance of agencies.

The legal basis of air pollution control policy should provide for more substantial participation of citizens, better opportunities for issuing improvement orders to old emitting sources, and better right of action for those seeking compensation for damage through air pollution. Concerning the latter, experience can be drawn from Japan and the United States. Particular consideration should be given to the reversed burden of proof, strict liability clauses, plausibility or epidemiological approaches to proving cause-effect relationships, and class action. Such approaches would create, at least, a greater degree of equity for those suffering from pollution and induce polluters to give up their carefree attitude. Of course, to incorporate such principles into existing law would not only be a troublesome political task but also a very complicated legal task because some fundamental principles of traditional law would have to be changed or even abandoned. In the FRG, discussion on this subject has started only recently and, at this stage no definite statement on the outcome can be made.

There is a bulk of literature dealing with the economic inefficiency of West German air pollution control policy. Especially economists have recommended to make market-type incentives part of air pollution control programmes or, in

general, to introduce more flexible instruments which would leave more room for discretion to emitters in selecting the most economical means of pollution abatement.

From the multitude of potentially available new instruments and approaches to air pollution control, the following ones have been given most attention: pollution charge or fee systems for emissions, resource taxes, emission trading ("off-set" policy, transferable emission permits, emission banking), "bubble" policy, and pollution control agreements. In the past, politicians evidently opted for instruments not recommended by economists, such as standards, directives, licenses, prohibitions and other regulatory instruments. To a small extent, traces of offset and bubble policies can be found, but these approaches have not been used systematically enough to create economic incentives for emitters to reduce emissions more than the law calls for. Even now, after an intensive debate on the shortcomings of existing approaches and possible alternatives, there is no consensus on the advantages of new instruments. However, there are clear indications that bubble policies are preferred, especially by the government, whereas transferable emission permits and emission banking are rejected by most experts. Charges on the emission of major air pollutants (especially SO_2) have been suggested not only by independent experts, but also by the Green Party and the government of Hesse. Nevertheless, both industry and the federal government are in strict opposition to such measures. This also applies for resource taxes. In an official statement, the Minister of the Interior recently declared that charging emission fees would not lead to any improvements worth speaking of. Claims for introducing a fee system he put off as being mere ideology.

Pollution control agreements between public authorities and enterprises did occur now and then. However, in most cases they were not successful because the firms did not keep their "promises" and the authorities had no legal means to

enforce what was more like a "gentlemen's agreement".

The regulatory approach prevails in West Germany's air pollution policy because of this country's politico-administrative culture. Administrators (and technical experts at factory inspectorates, who are in many cases also the authorities responsible for air pollution control) are more accustomed to applying standards and regulations than to managing economic transfers. Although they are notorious for complaining about "strangling" bureaucratic regulations, firms and business federations actually prefer the status quo over solutions involving payments. Furthermore, the public and, especially, environmental protection groups are rather reluctant to accept the idea of introducing more economic and flexible instruments because they anticipate a strong tendency towards selling pollution rights. Despite objections to and misgivings about economic and more flexible instruments, there is a broad-based consensus that existing air pollution control policy should be made more efficient and attractive to emitters through a "mixture of instruments", for instance, a combination of regulatory and economic measures. The only "economic instruments" used extensively by federal and state governments are allocation of subsidies, tax reductions, accelerated depreciation, and low-interest loans for environmental protection investment.

VI RECOMMENDATIONS

1. Areas for Further Research, Monitoring and Assessment

Comparatively little has been done in the FRG to investigate the relationship between air pollution and health problems. There is also a substantial need for more research and monitoring to allow for more effective response to problem situations caused by air pollution and better anticipation of emerging problems. In a more substantial sense, there is a need for research on the concept and methodology of a pre-ventive environmental policy, i.e., the basic condition for a departure from the present react-and-cure approach to anticipatory action. This is a very broad area for further research, and even summarising the several aspects to be dealt with by such research would go far beyond the scope of this study. However, the importance of research on strategies for implementing new approaches under present political, social and administrative conditions should be emphasised. Studies on new approaches have often failed to answer the pivotal question: how would the existing system react? Correspondingly, there is a basic need for more research on the roles played by the energy supply system in formulating and implementing air pollution control policies. Furthermore, conditions for and constraints to international cooperation in air pollution control have, as yet, not been sufficiently investigated.

As mentioned in the previous section, much research has been done on the issue of how to create more incentives for emitters to do more in air pollution abatement than is required by law. This question should also be directed to administrators. There are clear indications that they have not made full use of their political power and the legal possibilities to reduce air pollution. Thus, last but not least, research is needed on incentives to increase administrators' activities in reducing and preventing air pollution.

2. Recommendations

According to official statements of West German politicians responsible for national clean air policy, the FRG has the most progressive, modern and successful air pollution control policy in Europe. As the preceding sections tried to show, this favourable self-assessment is based primarily on rather formal aspects, such as the quantity of laws, regulations, and administrative resources directed to air pollution problems. Indeed, the number of air pollution control laws and regulations is impressive. No other country--with the exception of the U.S.A.--has established such a comprehensive, detailed and complex system of legal and administrative regulations for air pollution control. However, considering the actual performance of this regulatory system, the self-ascribed achievements seem highly questionable. Emissions of major air pollutants have been reduced only marginally or have even increased. New pollutants of a more complex, toxic nature raise growing concern. Improvements in the ambient air quality of urban and industrial agglomerations have been, for a large part, the result of the high chimney strategy, contributing decisively to the deterioration of air quality in rural areas. Not only the public has for many years been worrying about slow progress or deterioration, but also economic groups have pointed at severe deficiencies of the approaches used. Finally, the dramatic increase in damage to forests, growing concern with acute and chronic injuries to health, indications of massive and partly irreversible damage to buildings and monuments, as well as detrimental impacts on other natural resources, coupled with slow and limited response by authorities and politicians support the contention that West Germany's air pollution control policy has failed not only to prevent damage, but also, to a large extent, to handle environmental damage appropriately. Thus, until recently, the country's air pollution control policy could not be considered as a shining example for other countries. However, other countries could learn from the mistakes and causes underlying them in order to avoid similar experiences (see section V above).

As mentioned earlier, the unfavourable assessment of West Germany's performance in air pollution control was correct until recently. Triggered by the dramatic increase in damage to forests, in parts quite ambitious new programmes for reducing emissions from automobiles and small, medium and large combustion plants were developed. Since implementation of these programmes did not start until quite recently, it is as yet not possible to assess the achievements. However, one conclusion can be drawn already at this stage: environmental consciousness and massive political protest by citizen groups against polluters and insensitive authorities provide basic impetuses to government action. Thus, a general recommendation for all countries aiming seriously at a better air quality control policy would be to promote environmental consciousness and to establish ways and means for a substantial participation of citizens in environmental policy and causally inter-related policy areas, such as energy policy.

VII CONCLUSION

The "modern phase" of West German air pollution control policy started in the early 1970s, largely on the initiative of the federal government since the general public was little aware of air pollution problems and hardly involved in that area. During the 1970s this situation changed radically. In spite of the numerous legal provisions for emission control, damage to forests and human health increased, and air pollution became one of the dominating political issues. Since then, increasing public concern about air pollutants, especially those emitted by conventional power plants and automobiles, "mushrooming" citizen initiatives, as well as the formation of environmental protection organisations and "Green Parties" have been the major stimuli for improving air pollution control policy, whereas government, industry and trade unions have more or less adhered to their restrictive attitude to rigorous clean air measures. A new phase of reinforced air pollution control policy began in 1982. This phase, which is still going on, was mainly set in motion by the intense public debate on the impacts of air pollution on health, forests and the ecosystem as a whole. In that same year, a new federal government took over. It responded to this challenge by passing new and stricter legal requirements for stationary and mobile sources, initiating EEC legislation on air pollution control, and creating some economic incentives for pollution control measures such as tax reductions and subsidies. These activities--partly accompanied by additional measures of some state and local governments--are expected to achieve massive reductions in the emission of major air pollutants and to overcome some of the weaknesses of previous air pollution control law. Of special interest is a certain shift in air pollution control strategy from the former "broad" approach of covering all emission sources with structurally rather similar legal requirements to a more selective problem and emission-oriented approach. Especially the TI Air of 1985 provides for selective interventions by responsible authorities according to

the risk potential of emitting sources and/or pollutants and cost-benefit relations of pollution abatement measures. The Ordinance on Large Combustion Plants of 1983--particularly in combination with the strict NO_x emission standards adopted by the conference of the federal and state ministers responsible for the environment (Umweltministerkonferenz) in 1984--established clear-cut objectives for fixed time periods, thus adopting a technology forcing approach, at least for NO_x emissions by large combustion plants. If the new legal requirements will be enforced as announced by government an important and favourable change in air pollution control strategy would be made.

Since about 1974, the FRG has had the most comprehensive and detailed air pollution control law of all European countries. There is a strong tendency rooted in the specific politico-administrative culture of the FRG and particularly adhered to by legally trained bureaucrats to strive for an almost loophole-free system of legal regulations for all aspects of programme formulation and implementation in the area of air pollution control. The relevant articles and provisions to be taken into consideration in air pollution matters cover hundreds of pages, and even legal and administrative experts admit that it is extremely difficult to get a full understanding of the total system. Nevertheless, there are certain major gaps and shortcomings which have been responsible for deficient implementation leading to increased environmental damage and conflict. Some of these shortcomings have been tackled by new legal provisions enacted since 1983. As mentioned above, they set the focus of air pollution control policy more on emissions from major polluting source (old and new), clear-cut objectives concerning some major air pollutants, and, partly, on a technology forcing approach by fixing definite time frames for the implementation of legal requirements. Since implementation has just begun, the effects can, as yet, not be assessed.

Although air quality will certainly be improved over the coming years, it is still unclear--and debatable--whether the new legal requirements will bring about substantial decreases in major air pollutants (especially NO_x) fast enough to save our endangered forests. Experts expect that the relatively weak exhaust standards for automobiles of the EEC directive will not decisively contribute to NO_x reductions. The recent decision of the federal government not to impose general speed limits for motorways (100 km per hour) and state highways (80 km per hour) caused strong criticism from various sides.

Air pollution control policy in the FRG has become more satisfactory since 1983. Nevertheless, some of the fundamental shortcomings identified by empirical implementation research have remained:

- o Clear objectives of air pollution control policy are only stated for some major pollutants.
- o Ambient air quality standards have been set for only a few pollutants. Compared to the state of scientific knowledge, the standard for SO_2 is particularly weak. Furthermore, these standards give no consideration to synergistic effects of two or more air pollutants and too little consideration to short-term peak concentrations of pollutants in the ambient air.
- o The three basic programmatic principles of air pollution control policy are still not sufficiently implemented:
 - The principle of "precaution" (prevention of damage instead of remedial action) is not substantially embedded in air pollution control programmes and standards. The reactive (as well as selective and peripheral) policy style is still dominating. Especially the long-term effects of environment-oriented interventions are not sufficiently considered leading to spatial, medial, and temporal "problem dislocation" (shifting pollutants from one area/medium to another or diluting pollution loads over a lengthy period of time).

- The "polluter pays principle" is only partly implemented. Even in areas in which the responsible groups of emitters are known, the "public pays principle" still prevails. Much public money is spent on direct/indirect subsidies to emitters whereas those suffering damage through air pollution do not receive compensation (e.g., forest owners).
- Contrary to the meaning of the "cooperation principle", environmental protection groups are allowed only limited access both to policy formulation and implementation processes.
- o Environmental monitoring and reporting still need substantial improvement. Reliable and comprehensive data on damages, emissions (especially from individual sources), and the ambient air quality situation are still lacking. Only very few operators of large and medium-sized plants monitor their emissions continuously, and there are no provisions for a direct and continuous transfer of emission data to the supervising agencies, e.g. by telemeter systems. Moreover, publication of emission data for individual sources is highly restricted.
- o The centralized, bureaucratic-regulatory type of air pollution control still prevails. Flexible instruments, which would allow enterprises to meet legal requirements on an optimal cost-benefit basis according to their special situation, are as rare as instruments providing incentives for emitters to do more than the law requires. The legal and organisational structure of air pollution control leaves only very limited possibilities to local authorities to adapt environmental policies to the specific conditions of their administrative areas.
- o Cost-benefit analyses of environmental policies do not give due consideration either to those benefits of stricter anti-pollution measures or to those costs of environmental damage that cannot be physically measured or calculated in exact economic terms, e.g., loss of amenities.

- o Most emissions of major air pollutants are the result of combustion processes in stationary and mobile sources. Energy saving policy, nevertheless, is not systematically pursued and utilisation of low-pollution or renewable energy sources is still in its infancy.
- o Finally, there are only very limited possibilities for citizens affected by pollution to influence government policy or the behaviour of emitters. Likewise, chances for citizens to seek remedy for damage by air pollution through court action are small. The existing (dogmatic) legal principles and rules for decision-making are much more in favour of those polluting the air than those suffering from air pollution.

To sum up: Air pollution control policy in the FRG has been improved considerably since 1983, primarily due to public pressure. However, to ensure long-term positive effects of initiated measures and to prevent the emergence of new problems, some basic shortcomings of the present approach in air pollution control are still to overcome. This will be a great challenge for politicians and administrators, since it would involve, among other things, a restructuring of the deep-rooted power position of energy supply companies which is still impeding rational air pollution control policy. In addition, a new international strategy must be developed to make other European countries as well as EEC institutions adopt common effective and anticipatory approaches to cope with transboundary air pollution problems. Disregarding euphonious declarations, there is, as yet, no promising indication that the German government is well prepared to perform this difficult task. But, to be fair, most EEC member countries facing the same problems are not doing any better.

VIII LITERATURE

- Arbeitskreis Chemische Industrie/Katalyse Umweltgruppe Köln (ed.), Das Waldsterben. Ursachen, Folgen, Gegenmaßnahmen, Köln 1983.
- Bauerschmidt, R.: "Energy Conservation in the Federal Republic of Germany". In: National Swedish Environment Protection Board, Strategies and Methods to Control Emissions of Sulphur and Nitrogen Oxides. Report SNV PM 1637, Solna 1983, pp. 119-128.
- Baur, W.: Krankheitshäufigkeit und Umweltbelastung: Beobachtungen aus einer Allgemeinpraxis. Lecture held at the Deutscher Kongress für Allgemeinmedizin, June 26, 1982, mimeo.
- Bayerisches Staatsministerium für Landesentwicklung und Umweltfragen (ed.), Umweltpolitik in Bayern, 2nd edition, Munich 1980.
- Bender, W., Jaklin, R., Emmerich, H. & Emmerich, W., "Umwelteinflüsse beim Krupp-Syndrom", Deutsches Ärzteblatt 1972, pp. 3135-3137.
- Binswanger, H., Bonus, H. & M. Timmermann, Wirtschaft und Umwelt - Instrumente einer Ökologieverträglichen Umweltpolitik, Stuttgart, etc. 1981.
- Binswanger, H., Frisch, H., Nutzinger, H.G., et al., Arbeit ohne Umweltzerstörung - Strategien für eine neue Wirtschaftspolitik, Frankfurt/M. 1983.
- Bölsche, J. (ed.), Das gelbe Gift. Todesursache: Sauer Regen, Reinbek 1984.
- Brunowski, R. & L. Wicke, Der Öko-Plan. Durch Umweltschutz zum neuen Wirtschaftswunder, Munich and Zurich 1984.
- Buchwald, K. & W. Engelhardt (eds.), Handbuch für Planung, Gestaltung und Schutz der Umwelt, Vol. 2, Munich 1978.
- Buck, M., et al., "Die Veränderungen der Immissionsbelastung in den letzten 15 Jahren im Rhein-Ruhr-Gebiet." Staub - Reinhaltung der Luft, Nr. 2/1982, pp. 51-58.
- Bundesministerium des Innern (ed.), Abschlußbericht der Projektgruppe "Aktionsprogramm Ökologie" - Argumente und Forderungen für eine ökologisch ausgerichtete Umweltvorsorgepolitik. Umweltbrief Nr. 29, October 28, 1983.
- Bundesministerium des Innern (ed.), Report of the Causes and Prevention of Damage to Forests, Waters and Buildings by Air Pollution in the Federal Republic of Germany. Report presented at the Multilateral Conference on the Environment, Munich, June 24-27, 1984. Bonn 1984.

- Bundesministerium des Innern (ed.), Was Sie schon immer über Luftreinhaltung wissen wollten. Stuttgart, etc. 1983.
- Bundesministerium für Ernährung, Landwirtschaft und Forsten (ed.), Waldschäden durch Luftverunreinigungen. Bericht des Herausgebers, des Bundesministerium des Innern und des Länderausschusses für Immissionsschutz, Bonn, October 25, 1982.
- Bundesregierung (ed.), Umweltprogramm 1971. Bundestags-Drucksache VI/2710, Bonn 1971.
- Bundesregierung (ed.), Umweltbericht 1976. Bundestags-Drucksache 7/5902, Bonn 1976.
- Bundesregierung (ed.), Erster Immissionsschutzbericht, Bundestags-Drucksache 8/2006, Bonn 1977.
- Bundesregierung (ed.), Zweiter Immissionsschutzbericht, Bundestags-Drucksache 9/1458, Bonn 1982.
- Bundesregierung (ed.), Dritter Immissionsschutzbericht, Bundestags-Drucksache 10/1354, Bonn 1984.
- Bundesverband der Deutschen Industrie/BDI (ed.), Umweltschutz und industrielle Entwicklung in der Bundesrepublik Deutschland, Cologne 1979.
- Deutsche Stiftung für Umweltpolitik (ed.), Umweltpolitisches Gespräch: Ökonomische Instrumente der Umweltpolitik. - Neuer Weg oder Sackgasse? Beiträge zur Umweltgestaltung A 93, Berlin 1984.
- Doran, C.F., Hinz, M. & P.C. Mayer-Tasch, Umweltschutz - Politik des peripheren Eingriffs, Darmstadt and Neuwied 1974.
- Dost, B., Die Erben des Übels. Kranke Umwelt, kranke Kinder. Munich 1983.
- Dreyhaupt, F.J., Handbuch zur Aufstellung von Luftreinhalteplänen, Cologne 1979.
- Dreyhaupt, F.J., Umweltschutz für Unternehmer, Cologne and Darmstadt 1978.
- The Economist Intelligence Unit Ltd. (ed.), A Study of the Practical Advantages and Disadvantages of the Instruments Used in the Environment Policies of Member States. Case Studies: The Federal Republic of Germany, July 1975, no place.
- Ehrlich, E.M., Lutton, T.S. & J.B. Thomasian, Environmental Regulation and Economic Efficiency. Congress of the United States, Congressional Budget Office, Washington, D.C., March 1985.

- Environmental Resources Ltd. (ed.), Acid Rain. A Review of the Phenomenon in the EEC and Europe. London 1983.
- Evangelische Akademie Loccum (ed.), Verwaltungsrecht in der Bundesrepublik Deutschland: Erfolge, Probleme, Perspektiven. Loccumer Protokolle Nr. 18, Rehburg-Loccum 1984.
- Feldhaus, G., Bundesimmissionsschutzrecht. Kommentar und Rechtsvorschriften, 2nd edition, Wiesbaden 1974ff. (loose-leaf edition).
- Feldhaus, G., "Der Vorsorgegrundsatz des Bundes-Immissionsschutzgesetzes", Deutsches Verwaltungsblatt Nr. 4/1980, pp. 133-139.
- Feldhaus, G. & H. Ludwig, "Die TA-Luft 1983", Deutsches Verwaltungsblatt Nr. 11/1983, pp. 565-574.
- Fritsche, U., Schebek, L. & C. Schubert, Rettung für den Wald. Strategien und Aktionen. Frankfurt/M. 1984.
- Gewerbeaufsicht des Landes Nordrhein-Westfalen (ed.), Jahresberichte. Düsseldorf, various years.
- Hartkopf, G. & E. Bohne, Umweltpolitik. Vol. 1: Grundlagen, Analysen und Perspektiven, Opladen 1983.
- Hatzfeldt, H. (ed.), Kohle. Konzept einer umweltfreundlichen Nutzung. Frankfurt/M. 1982.
- Hatzfeldt, H. (ed.), Stirbt der Wald? Karlsruhe 1982.
- Heinz, I., "Volkswirtschaftliche Kosten durch Luftverunreinigungen". In: Institut für Umweltschutz der Universität Dortmund (ed.), INFU Werkstattreihe Vol. 4, Dortmund 1980.
- Hoppe, W., Wirtschaftliche Vertretbarkeit im Rahmen des Bundes-Immissionsschutzgesetzes. Stuttgart 1977.
- Hübler, K.-H. (ed.), Bodenschutz als Gegenstand der Umweltpolitik. Berlin 1985.
- Hübler, K.-H., "Die Zerstörung des Umweltmediums Boden." In: M. Jänicke, U.E. Simonis & G. Weigmann (eds.), Wissen für die Umwelt. 17 Wissenschaftler bilanzieren. Berlin and New York 1985.
- Ingenieurbüro für rationellen Energieeinsatz, Lösungsmöglichkeiten zur Schadstoffminderung und Kondensataufbereitung in Haushalt und Kleinverbrauch. Boppard 1985.
- Institut für Energie- und Umweltforschung Heidelberg, Die Entwicklung der Schadstoffemissionen aus dem Kfz-Verkehr. Eine Bilanz der Auswirkungen der EG-Beschlüsse und der steuerlichen Anreize zum schadstoffarmen Pkw. IfEU-Bericht Nr. 42, Heidelberg 1985.

- Institut für Energie- und Umweltforschung Heidelberg, Materialien zum Waldsterben. Wirksamkeitsanalyse emissionsmindernder Maßnahmen. Schwefeldioxid, Stickoxide. IFEU-Bericht Nr. 40, 2nd enlarged edition, Heidelberg 1985.
- Jänicke, M., Wie das Industriesystem von seinen Mißständen profitiert, Opladen 1979.
- Jahn, A. & H. Palamidis, "Kurzfristige Auswirkungen der Luftverschmutzung auf die Mortalität in Berlin (West) 1976-1982." Berliner Statistik Nr. 5/1983, pp. 112-115.
- Jarass, H.D., Bundesimmissionsschutzgesetz. Kommentar. Munich 1983.
- Kalmbach, S., "Was bringt die neue TA-Luft?" Umweltmagazin Nr. 2/1983, pp. 18-22.
- Knödgen, G., The STEAG Coal-Fired Power Plant at Voerde or Changing German Clean Air Policy, IIUG dp 81-11, International Institute for Environment and Society, Science Center Berlin, Berlin 1981.
- Knoepfel, P. & H. Weidner, "Die Durchsetzbarkeit planerischer Ziele auf dem Gebiet der Luftreinhaltung aus der Sicht der Politikwissenschaft. Ergebnisse aus einer internationalen Vergleichsuntersuchung." Zeitschrift für Umweltpolitik, Nr. 2/1983, pp. 87-115.
- Knoepfel, P. & H. Weidner, "Formulation and Implementation of Air Quality Control Programmes: Patterns of Interest Consideration." Policy and Politics, No. 1/1982, pp. 85-109.
- Knoepfel, P. & H. Weidner, Handbuch der SO₂-Luftreinhaltungspolitik. Daten, Konzepte und rechtliche Regelungen in den EG-Staaten und der Schweiz. Vol. I: Vergleichende Analyse. Vol. II: Länderberichte. Berlin 1980.
- Knoepfel, P. & H. Weidner, "Implementing Air Quality Control Programs in Europe: Some Results of a Comparative Study." In: P.B. Downing & K.I. Hanf (eds.), International Comparisons in Implementing Pollution Laws. Boston, etc. 1983, pp. 191-211.
- Koch, E.R., Die Lage der Nation. Umwelt-Atlas der Bundesrepublik. Hamburg 1985.
- Landesanstalt für Immissions- und Bodennutzungsschutz des Landes Nordrhein-Westfalen (ed.), "Immissionsgefährdung der Wälder im Ruhrgebiet." Schriftenreihe der Landesanstalt für Immissions- und Bodennutzungsschutz, vol. 26/1972, pp. 83-87.
- Landesregierung Nordrhein-Westfalen (ed.), Umweltbericht Nordrhein-Westfalen. Düsseldorf 1974.

Landesregierung Nordrhein-Westfalen (ed.), Umweltschutz in Nordrhein-Westfalen. Düsseldorf 1980.

Leisner, W., Waldsterben. Öffentlich-rechtliche Ersatzansprüche. Cologne, etc. 1983.

Lersner, H.v., "Clean Air Strategy in the Federal Republic of Germany." In: American Bar Association (ed.), Air Pollution Control: National and International Perspectives. Washington, D.C., 1980, pp. 28-30.

Lummert, R., The Legal Framework of Industrial Siting in Germany, IIUG dp 81-18, International Institute for Environment and Society, Science Center Berlin, Berlin 1981.

Lummert, R., Trends in Environmental Policy and Law: Changes in Civil Liability Concepts. IIUG pre 79-7, International Institute for Environment and Society, Science Center Berlin, Berlin 1979.

Mayntz, R. et al., Vollzugsprobleme der Umweltpolitik. Empirische Untersuchung der Implementation von Gesetzen im Bereich der Luftreinhaltung und des Gewässerschutzes. Stuttgart 1978.

Meißner, W. & E. Hödl, Umweltschutz in Konjunktur- und Wirtschaftsprogrammen. Umweltbundesamt, Berichte 1/83, Berlin 1983.

Mez, L. (ed.), Der Atomkonflikt. 2nd edition. Reinbek 1981.

Ministerium für Arbeit, Gesundheit und Soziales des Landes Nordrhein-Westfalen (ed.), Luftreinhalteplan Rheinschiene Mitte 1982-1986. Düsseldorf 1982.

Ministerium für Arbeit, Gesundheit und Soziales des Landes Nordrhein-Westfalen (ed.), Luftreinhalteplan Rheinschiene Süd (Köln) 1977-1981. Düsseldorf 1977.

Ministerium für Arbeit, Gesundheit und Soziales des Landes Nordrhein-Westfalen (ed.), Luftreinhalteplan Rheinschiene Süd - 1. Fortschreibung - 1982-1986. Düsseldorf 1983.

Ministerium für Arbeit, Gesundheit und Soziales des Landes Nordrhein-Westfalen (ed.), Luftreinhalteplan Ruhrgebiet Mitte 1980-1984. Düsseldorf 1980.

Ministerium für Arbeit, Gesundheit und Soziales des Landes Nordrhein-Westfalen (ed.), Luftreinhalteplan Ruhrgebiet Ost 1979-1983. Düsseldorf 1978.

Ministerium für Arbeit, Gesundheit und Soziales des Landes Nordrhein-Westfalen (ed.), Luftreinhalteplan Ruhrgebiet West 1978-1982. Düsseldorf 1977.

Ministerium für Arbeit, Gesundheit und Soziales des Landes Nordrhein-Westfalen (ed.), Reinhaltung der Luft in Nordrhein-Westfalen. Düsseldorf 1969.

- Offermann-Clas, C., Luftreinhaltung in der Bundesrepublik Deutschland. Gesetzliche Grundlagen, Voraussetzungen, Verfahren und zuständige Behörden für die Genehmigung emittierender Anlagen. Cologne 1984.
- Pfeffer, H.-U., "Das telemetrische Echtzeit-Mehrkomponenten-Erfassungssystem TEMES zur Immissionsüberwachung in Nordrhein-Westfalen." Staub - Reinhaltung der Luft Nr. 6/1982, pp. 233-236.
- Presse- und Informationsamt der Bundesregierung (ed.), Umweltpolitik - Aufgabe der Gegenwart und Zukunft. Berichte und Dokumentationen Nr. 16. Bundestags-Drucksache Nr. 8/3713, Bonn 1980, pp. 57-78.
- Prittwitz, V., Smogalarm. Fünf Funktionen der unmittelbaren Gefahrenabwehr im Umweltschutz. IIUG pre 85-10, International Institute for Environment and Society, Science Center Berlin, Berlin 1985.
- Prittwitz, V., Vorausgreifende Smogbekämpfung. Materialien und Überlegungen zum Stand der Luftreinhaltungspolitik in Ballungsräumen der Bundesrepublik Deutschland. IIUG dp 81-5, International Institute for Environment and Society, Science Center Berlin, Berlin 1981.
- Der Rat von Sachverständigen für Umweltfragen (ed.), Energie und Umwelt. Sondergutachten, März 1981. Stuttgart and Mainz 1981.
- Der Rat von Sachverständigen für Umweltfragen (ed.), Umweltgutachten 1974. Stuttgart and Mainz 1974.
- Der Rat von Sachverständigen für Umweltfragen (ed.), Umweltgutachten 1978. Stuttgart and Mainz 1978.
- Der Rat von Sachverständigen für Umweltfragen (ed.), Waldschäden und Luftverunreinigungen. Sondergutachten März 1983. Stuttgart and Mainz 1983.
- Rehbinder, E., "Allgemeines Umweltrecht." In: J. Salzwedel (ed.), Grundzüge des Umweltrechts. Berlin 1982, pp. 81-115.
- Rehbinder, E., "Implementation of Air Pollution Control Programs Under the Law of the Federal Republic of Germany." In: American Bar Association (ed.), Air Pollution Control: National and International Perspectives. Washington, D.C., 1980, pp. 31-32.
- Rehbinder, E., Politische und rechtliche Probleme des Verursacherprinzips. Berlin 1973.
- Rengeling, H.W., "Die immissionsschutzrechtliche Vorsorge als Genehmigungsvoraussetzung." Deutsches Verwaltungsblatt Nr. 13/1982, pp. 622-629.
- Salzwedel, J. (ed.), Grundzüge des Umweltrechts. Berlin 1982.

Salzwedel, J. & W. Preusker, The Law and Practice Relating to Pollution Control in the Federal Republic of Germany. 2nd edition. London 1982.

Schütt, P. et al., So stirbt der Wald. Munich 1983.

Senator für Stadtentwicklung und Umweltschutz Berlin (ed.), Luftreinhalteplan 1981, Teilplan Schwefeldioxid. Berlin 1981.

Sendler, H., "Wer gefährdet wen: Eigentum und Bestandsschutz den Umweltschutz - oder umgekehrt?" Umwelt- und Planungsrecht Nr. 2/1983, p. 38.

Siebert, H. (in cooperation with W. Vogt), Analyse der Instrumente der Umweltpolitik. Göttingen 1976.

Sprenger, R.-U., Beschäftigungseffekte der Umweltpolitik. Berlin 1979.

Sprenger, R.-U. & G. Knödgen, Struktur und Entwicklung der Umweltschutzindustrie in der Bundesrepublik Deutschland. Umweltbundesamt, Berichte 9/83, Berlin 1983.

Storm, P.-C., Umweltrecht. Einführung in ein neues Rechtsgebiet. Berlin 1980.

Technischer Überwachungsverein (TÜV) Rheinland/Institut für Energietechnik und Umweltschutz, Abgas-Emissionsszenarien für den Pkw-Verkehr in der Bundesrepublik Deutschland unter Berücksichtigung der Beschlüsse der EG-Umweltministerkonferenz. Cologne 1985.

Ulrich, B. & E. Matzner, Abiotische Folgewirkungen der weiträumigen Ausbreitung von Luftverunreinigungen. Forschungsbericht Nr. 104 O3 615 im Auftrag des Umweltbundesamtes. Berlin 1983.

Umwelt. Informationen des Bundesministers des Innern zur Umweltplanung und zum Umweltschutz, various years.

Umweltbundesamt (ed.), Altanlagenreport 1979. Berlin 1980.

Umweltbundesamt (ed.), Luftqualitätskriterien. Umweltbelastung durch Asbest und andere faserige Feinstäube. Berlin 1980.

Umweltbundesamt (ed.), Cadmium-Bericht. Texte 1/81, Berlin 1981.

Umweltbundesamt (ed.), Daten zur Umwelt 1984. Berlin 1984.

Umweltbundesamt (ed.), Functions and Organization of Environmental Protection in the Federal Republic of Germany. Berlin 1984.

Umweltbundesamt (ed.), Jahresberichte 1978-1983, Berlin 1978ff.

- Umweltbundesamt (ed.), Luftreinhaltpolitik '81. Entwicklung - Stand - Tendenzen. Berlin 1981.
- Umweltbundesamt (ed.), Luftverschmutzung durch Schwefeldioxid. Ursachen, Wirkungen, Minderung. Texte, Berlin 1980.
- Umweltbundesamt (ed.), Materialien zum Immissionsschutzbericht 1977 der Bundesregierung an den Deutschen Bundestag. Berlin 1977.
- Umweltbundesamt (ed.), Materialien zum Immissionsschutzbericht 1981 der Bundesregierung an den Deutschen Bundestag. Berlin 1982.
- Umweltbundesamt (ed.), Medizinische, biologische und ökologische Grundlagen zur Bewertung schädlicher Luftverunreinigungen. Sachverständigenanhörung, Berlin, February 20-24, 1978. Wortprotokoll und Materialien. Berlin 1978.
- Weidner, H., Die gesetzliche Regelung von Umweltfragen in hochentwickelten kapitalistischen Industriestaaten. Eine vergleichende Analyse. Schriftenreihe des Fachbereichs Politische Wissenschaften der Freien Universität Berlin. Berlin 1975.
- Weidner, H., "SO₂-Luftreinhaltepolitik in der Sackgasse? Die Bundesrepublik im internationalen Vergleich." Umweltmagazin. Fachzeitschrift für Umwelttechnik in Industrie und Kommune Nr. 6/1983, pp. 22-24.
- Weidner, H., "Von der Schadstoffbeseitigung zur Risikoverhinderung. Neue gesetzliche Regelungen für Umweltchemikalien." Aus Politik und Zeitgeschichte (supplement to the weekly Das Parlament) B44/1977, pp. 34-42.
- Weidner, H. & M. Jänicke, "Optische Täuschungen im Umweltschutz." Umschau in Wissenschaft und Technik Nr. 22/1977, pp. 722-729.
- Weidner, H. & P. Knoepfel, "Implementationschancen der EG-Richtlinie zur SO₂-Luftreinhaltepolitik. Ein kritischer Beitrag zur Internationalisierung von Umweltpolitik." Zeitschrift für Umweltpolitik Nr. 1/1981, pp. 27-68.
- Weidner, H. & P. Knoepfel, "Innovation durch international vergleichende Politikanalyse. Dargestellt am Beispiel der Luftreinhaltepolitik." In: R. Mayntz (ed.), Implementation politischer Programme II. Opladen 1983, pp. 221-255.
- Weidner, H. & P. Knoepfel, Luftreinhaltepolitik im internationalen Vergleich: Bundesrepublik Deutschland. Berlin 1985.
- Weidner, H. & P. Knoepfel (eds.), Luftreinhaltepolitik in städtischen Ballungsräumen. Ein internationaler Erfahrungsaustausch. Frankfurt/M. and New York 1985.

- Weidner, H. & P. Knoepfel, "Normbildung und Implementation. Interessenberücksichtigungsmuster in Programmstrukturen von Luftreinhaltungspolitiken." In: R. Mayntz (ed.), Implementation politischer Programme. Empirische Implementationsforschung. Königstein/Ts. 1980, pp. 82-104.
- Weidner, H. & P. Knoepfel, "Politisierung technischer Werte. Schwierigkeiten des Normbildungsprozesses am Beispiel der Umweltpolitik." Zeitschrift für Parlamentsfragen Nr. 2/1979, pp. 160-170.
- Weidner, H. & S. Tsuru (eds.), Ein Modell für uns: Die Erfolge der japanischen Umweltpolitik. Cologne 1985.
- Weidner, H. & S. Tsuru (eds.), Environmental Policy and Politics in Japan. Berlin 1986 (in preparation).
- Wey, K.-G., Umweltpolitik in Deutschland. Kurze Geschichte des Umweltschutzes in Deutschland seit 1900. Opladen 1982.
- Wicke, L., "Zur Notwendigkeit von flexiblen Lösungen in der bundesdeutschen Umweltpolitik." In: H.G. Pohl (ed.), Saubere Luft als Marktprodukt. Hamburg 1983, pp. 13-29.
- Wippermann, F.K., "Was ergeben die Abschätzungen des Ferntransports von Luftverunreinigungen?" In: Ministerium für Arbeit, Gesundheit und Soziales des Landes Nordrhein-Westfalen (ed.), Hohe Schornsteine als Element der Luftreinhaltungspolitik in Nordrhein-Westfalen. Düsseldorf 1981, pp. 25-38.
- Zimmermann, H., Ökonomische Anreizinstrumente in einer auf-lagenorientierten Umweltpolitik. Bericht an den Rat von Sachverständigen für Umweltfragen. Marburg 1982.