COMMISSION OF THE EUROPEAN COMMUNITIES

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PRELIMINARY REPORT ON THE PROBLES OF POLLUTION
AND NUISANCES ORIGINATING FROM ENERGY PRODUCTION

(with a special emphasis on SO_2, particulate matter, NO_x and thermal discharges)

(submitted to the Council by the Commission)

CONTENTS

I. INTRODUCTION AND SUMMARY OF CONCLUSIONS

1. In accordance with the Action Programme of the Environment (Part II, title I, Chapter 5, Section 2) approved by a declaration of the Council of November 1973, and in accordance with the decision of the Energy Council meeting of March 22, 1973, the Commission is sending to the Council a preliminary report on the pollution and nuisance problems which arise from the production of energy. The complexity of the subject, the search -sometimes difficult- for an objective basis for judgement, the necessity to take into account the most recent factors in evaluating the medium-term prospects for production, the fluid and changing character of certain economic data as a result of recent events - all this explains why this report of about 42 pages has only been sent at this date.

2. As the Programme indicates, the report treats in a detailed manner three types of pollution which are particularly important: thermal discharges, sulphur dioxide emissions and nitrogen oxides. It is to be discussed with national experts and in the light of these discussions the Commission will make proposals to the Council as soon as possible and at the latest by the 31st July, 1974.

3. This report clearly demonstrates the following:

   a) taking account of present forecasts for the economic development of the Community, an annual increase in the use of energy of around 4.5% a year until 1985 has been assumed as a working hypothesis. Nevertheless, the implementation of new political and economic strategies may serve to reduce this rate to a less high level. The Commission proposes to send to the Council propositions to this effect in the shortest possible time;

   b) besides the shortage of certain natural resources - especially oil, coal, uranium - which will certainly be increased by it, this rise in energy production will pose certain environmental problems which could become serious if adequate attention is not given now to their nature and extent. Examples are:

      - the increase in atmospheric pollution especially in most urban or industrial areas which are already affected by this kind of pollution,
      - heating of water which may at a certain point noticeably affect ecological equilibria,
      - the effects of the production, transformation and use of energy on water supply,
      - problems of land-use arising from the increase in the number and capacity of new power plants and other installations to the brought into operation.

The table 1 attached at the end of this chapter shows the probable evolution of specific pollutions relevant to energy production considered in this report, if no new abatement measures are taken from now on.

c) The maintenance of a substantial level of energy use and transformation and the need to protect the environment must not in the context of a long term policy be considered contradictory or opposing objectives. Energy enables mankind not only to satisfy a certain number of economic and social needs; it is also an important factor in improving the conditions and quality of life, including of course the environment itself.

In a certain way, a rational approach to energy can be considered an essential element in an environment policy considered in the broad sense of qualitative as well as quantitative development.

4. In most respects, the need to conserve energy resources and the requirements of sound environmental management will go-hand-in-hand. Techniques for recycling, for the reutilization of waste (e.g. waste oils and waste paper), for the recovery of materials not only have important implications for the environment - e.g. in the reduction of pollution. They may equally have importance for the saving of energy and for the conservation of resources in the widest sense.

5. This is the context in which the Council's request must be placed. Certainly, there are some respects in which the concern for environmental protection may impose constraints on energy use or may add to its cost. But to present the energy-environment issue solely in terms of conflict is to distort the picture. Energy and environment are allies, not enemies. This relationship will be explored in greater depth in subsequent reports by the Commission to the Council, and notably in the general report on waste which the Council has asked for before July 31, 1974.

6. There are in any case other sound reasons for not relaxing now for reasons of actual difficulties in oil supply the efforts destined to improve the quality of our future environment. One has to bear in mind that decisions in the field of environmental protection as well as in the energy sector have long-term consequences and should not be governed by temporary disturbances and fluctuations of the market. The key decisions, for energy production as well as for environmental protection, essentially are those which relate to the investments which have to be made and their economic lifetime; these decisions must be taken in the frame-work of medium and long-term forecasts of developments in both fields.

7. Taking into account the time lag of four to six years between the authorization and the commissioning of a new power plant, and considering also that the average economic lifetime of a plant (*) is perhaps twenty years, it is clear that the decision to construct is in fact one that will have consequences for a substantial period of time, since during the lifetime of the plant pollutants will be discharged to the atmosphere and will influence air quality around the site and perhaps elsewhere.

8. Similar considerations apply to mobile installations. It is possible to reduce motor vehicle emissions up to a certain point without too heavy investments being imposed on manufacturers. However, beyond this point, considerable investment efforts may be necessary on the part of industry. Design changes can often take years to introduce. Decisions taken today on product and emission standards are decisions about the quality of the air in our cities not so much now as several years ahead. To postpone action now, because of short-term considerations, is to jeopardize the success of our efforts in the future.

9. It is the task of public authorities and interested parties at all levels to analyse the factors that influence demands for energy and to develop as soon as possible energy systems that meet these demands with maximum efficiency but with minimal damage to the environment. To improve the use of fuels in this sense (i.e. having regard at the same time to both efficiency <u>and</u> the environment) not only where the production of energy is concerned but also of those goods and services which directly or indirectly require the use of fuels appears more than ever before necessary if the harmonious economic development of the Community and, in a larger sense, the progress of humanity itself, is to be assured.

10. It will also be necessary to review at the various levels the energy and materials requirements of different economic activities and to consider in what way patterns of use can be improved the more rigorous introduction of recycling techniques, technological improvements or the modification of certain forms of production.

11. At the same time, whenever new power plants and other installations are being considered, attention must be paid both in the design and the siting of these installations, to measures necessary, taking into account technical and economic possibilities to ensure the respect of the environment in its wide sense (quality of life, as well as protection of nature).

As far as concerns three types of pollution which are the particular subject of this report, it is clear that measures must be taken as rapidly as possible to improve the situation both in the short and medium term, and to provide the means to ensure the respect of such measures.

(*) By the same token, certain investments in pollution control will need to be considered not only in the light of immediate needs but also in view of the future evolution of technology and/or environmental quality requirements.

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12. In particular, the report stresses the most urgent long-term problems posed by thermal discharges. It is anticipated that between now and the end of the century, well over 200 new power plants will need to be installed within the EEC countries and that the total quantity of heat discharged into the environment by power plants may increase by at least a factor of 8 as compared to the situation in 1970. This could have severe environmental consequences unless steps are taken. The report emphasizes the importance of:

(1) collecting data and improving knowledge of the effects of thermal discharges on the environment;

(2) planning the siting of new plants on a European basis, through the organized exchange of information among EEC Member states. This planning will need to take account not only problems of thermal pollution as such, but also wider questions such as the desalination potential of nuclear plants (which may be of special importance in the light of the water su pply situation in Europe) and the potential utilization of waste heat (see 4 below);

(3) generally to equip new power plants with cooling towers and to improve, as rapidly as possible, the design and technology of dry cooling towers so as to diminish the disadvantages which these still present where certain aspects of the environment are concerned;

(4) utilizing by all appropriate means waste heat produced by power plants, especially nuclear plants.

The Commission expects to make specific proposals in each of these four areas, including proposals for the exchange of information and R and C contracts.

13. The report makes several proposals for dealing with pollution problems caused by sulphur dioxide (SO_2). In addition to the draft directive on the sulphur content of gas-oils which has already been sent to the Council, the Commission is preparing a directive on the use of low-sulphur residual fuel-oils within certain zones (such as highly industrialized or highly populated zones) where pollution by SO_2 is already severe or could become so unless action is taken. Emphasis is placed on the need to achieve a more rational allocation of naturally clean fuels (e.g. natural gas and low-sulphur crude oils) to those areas and users which have most need of such fuels. Given the importance of desulphurization, the Community should develop this process as well as other techniques designed to limit the

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emission of SO_2 in the atmosphere both directly by means of contracts for research and development and by the promotion of demonstration projects, as well as by encouraging the exchange of information.

14. As far as nitrogen oxides (NO_x) are concerned, the principal conclusion of the report is that there exist at the moment large gaps in our knowledge which need to be filled. These concern both the effects of nitrogen oxides on man and the environment as well as the technical processes of pollution reduction, and also the appropriate methods of measurement. While waiting for an improvement of knowledge in this field, certain precautionary measures, in respect of both stationary and mobile sources of NO_x, could be taken.

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TABLE I [illegible] POLLUTION FROM ENERGY PRODUCTION AND USE

WITHIN EC - MEMBER STATES IF NO NEW CONTROL MEASURES ARE APPLIED

POLLUTION BY		1970	1975	1980	1985
Sulphur dioxide (SO_2) *) million tons/year	Stationary combustion installations only: Gas-oils Fuel-oils	2.2 5.8	2.7 14.8	3.2 17.2	-
Particulate matter million tons/year	Stationary combustion instal- lations only: - Domestic - Industry - Power plants	0.75) (1968) 0.70) 2.27 0.82)	-	0.40) 0.75) 1.80 0.65)	-
Nitrogen oxides (NOx) millions tons/ year	Stationary combustion instal- lations - Domestic heating etc - Industry - Power plants Mobile installations	0.8) 2.5) 5.4) 2.1)) 7.6 2.2)	0.9) 2.7) 6.2) 2.6)) 9.0 2.8)	1.1) 3.3) 7.5) 3.1)) 11.1 3.6)	1.2) 3.8) 8.5) 3.5)) 13.0 4.5)
Thermal discharges total heat rejected within the year to water and air from all types of thermal power plants Terawatthours **)	Hypothesis A to water to air	1,020)) 1,024 4)	1,520)) 1,540 20)	2,200)) 2,270 70)	3,220)) 3,390 170)
	Hypothesis B to water to air	idem	1,560)) 1,580 20)	2,390)) 2,460 70)	3,940)) 4,220 280)
Number of new sites to install within 5 year period	Hypothesis A Hypothesis B	Total number between 1970 and 1985: 119 121	41 41	37 39	41 41

*) With regard to the considerations under way on the future development of coal mining activities the data concerning SO_2 emissions from combustion of coal were not available upon writing this report. The Commission will make an effort to complete later on this table on that point.

**) Terawatthours = 860,000,000,000 Kcal

II. IMPORTANCE OF ENERGY PRODUCTION AND TRENDS IN FUTURE DEMAND

15. Statistical evidence exists for a direct correlation between economic growth measured in terms of gross national product and total growth in energy demand. For virtually all nations, the developing as well as the developed, the larger the per capita gross national product, the larger the per capita commercial energy consumption /Ref. 1,2/ The transition from an agrarian to an industrial economy has required a large increase in energy consumption both for powering industry and for raising productivity in agriculture. At the same time, the development of tight-woven transportation systems has also required a substantial share of total energy needs.

16. During the last fifty years worldwide energy production from commercial energy sources (coal, lignite, petrol, natural gas, hydroelectric, geothermal and nuclear energy) measured in energy terms has increased by a factor of more than 40.

As long as nations continue their efforts towards more welfare, which is measured at present in terms of gross national product per capita, it is reasonable to expect that the per capita energy consumption will also rise. Taking into account different hypotheses about future economic developments and growth rates and starting from the about 7,5 billion t.c.e.*) consumed in 1970, numerous forecasts /Ref. 3,4,5/of world energy demand in the year 2000 indicate values between 18 to 30 billion t.c.e., that is an increase by a factor of 2,5 to 4 (or an annual growth rate of 3,1 to 4,7%). (**)

17. According to the forecasts, the industrialized 9 Member States of the Communities appear to have a similar development in terms of specific energy consumption per capita. After a total energy consumption of 1.2 billion t.c.e. in 1970 the forecasts /Ref. 6,7,8/ envisage about 2.2-2.4 billion t.c.e. in 1985 and perhaps 3.6-4.5 billion t.c.e. in the year 2000; this means an increase by a factor of 3.0-3.7 over the entire period (or an annual growth rate of 3.7-4.5%). (**)

18. Worldwide electricity production has increased by a factor of more than 40 over the last fifty years. This trend is evident also within the EEC. Over the past two decades electricity consumption within most of the Member States has grown at a rate of over 7% annually, thus doubling in each decade. Considering all the factors likely to influence future demand, there is strong evidence that electricity production will experience a similar growth rate for the next decade. By the year 2000, about 50% of all energy will be used to produce electricity against the present figure of about 25%.

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*) t.c.e. = metric ton coal equivalent
(**) see footnote page 9

For these reasons particular attention has to be given to the environmental problems related to electricity production.

19. The following tables 2 and 3 illustrate the important increase expected for the energy requirements of the 9 EC Member States, till to 1985. The data (effective and forecasted) are broken down by sector and by energy source. In order to illustrate the important role which electricity is destined to play in the future global energy pattern, in table 2 the energy equivalent of the power plant production is indicated separately; in table 3 the total electricity production and its energetical equivalent is given together with a breakdown of the share of electricity production by the different types of fuel.

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(**) Footnote to points 16, 17 and 18:

The values which figure in paragraphs 16 to 18 as well as in tables 2 and 3 were calculated before the present energy crisis. These figures therefore can only be considered as working hypotheses which will need to be changed in the light of new strategies for less rapid growth in the economy and in the use of energy.

Table 2 : Energy requirements and forecasts by sector for the 9 EC-Member States 1)
(in million tons coal equipment)

Sector / Year	1970	1975	1980	1985
Industry	430	533	682	860
Domestic	399	493	626	780
Transportation	150	191	241	309
Auxiliary consumption and losses	131	159	196	232
Inland consumption 1)	1,110	1,376	1,745	2,181
Bunkers, exports and changes in stocks	130	157	174	197
Total energy requirements 1)	1,240	1,533	1,919	2,378
Power plants	303	397	548	748

1) Non-energetic uses excluded; forecasts as of mid-1973

Table 3 : Energy requirements and forecasts by source for the 9 EC Member States 1)

(in million tons coal equivalent)

Source / Year		1970	1975	1980	1985
Coal		377	296	270	249
Oil		713	961	1,210	1,481
Gas		89	187	275	355
Total		1,179	1,444	1,755	2,085
Gross electricity (TWh) production		(855,4)	(1,200)	(1,633)	(2,472)
(Mio tce)		303	397	548	748
of which:	Hydro	44	46	48	48
	Nuclear	15	38	98	273
	Natural gas	17	33	46	52
	Brown coal	24	30	36	38
	Hard coal	117	122	139	141
	Oil	76	117	167	179
	Derivated gases and others	10	11	15	18

1) non-energetic uses excluded; forecasts as of mid-1973

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III. ENERGY SUPPLY SYSTEMS AND THEIR ENVIRONMENTAL EFFECTS

III.1. Sources, magnitude

20. Energy is generally not available in a simple form but requires rather complex systems for its production, made up of a number of components which are necessary to bring a basic energy resource from its natural state to the place in which it is used. For most energy systems, this involves extraction, processing, often conversion into a more useful form, transportation between the various operations, transmission to the ultimate user, its final use and, eventually, disposal of residues.

21. As indicated above, the most important fraction of energy needs today is met by the combustion of fossil fuels, coal, oil and natural gas. Together they provide about 95% of the present demand and even by the year 2000 they will most probably will meet 50-60% of the needs. On the other hand, the share of hydropower in the total energy balance will decrease more and more. In the near future, nuclear power is likely to take at least an increasing part of electricity generation and within the next several decades nuclear energy may progressively replace the combustion of fossil fuels for many other energy uses.

22. Solutions designed to minimize the environmental effects of energy production have to take into consideration the overall impact of possible energy systems. The major problems can be highlighted as follows:

The conversion of fossil (and also nuclear) ~~fuels into~~ energy leads to:

- air pollution, mostly by gaseous products;
- water pollution by thermal discharges to cooling water and by wastes and by the transportation of fuels at sea or inland;
- solid wastes, and to land degradation by mining activities, processing of fuels and transportation of electric energy.

Another important issue closely related to energy production is the problem of the siting of installations destined to produce, transform or transport energy. The environmental impact of siting becomes particularly apparent with the thermal discharges from large power plants or with air and water pollution from refineries.

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III.2. Air pollution

23. It is generally acknowledged that combustion of fossil fuels is the most important source of air pollution. Among combustion products it is mainly sulphur dioxide (SO_2), nitrogen oxides (NO_x) and particulate matter that are considered as particularly detrimental to the environment and possibly hazardeous to human health. That is why in industrialized countries during the last years special attention has been given to these pollutants, to their origin, propagation and to possibilities of abatement.

24. Global estimates of air pollution for the important pollutants identify three principal sources of pollution:

- fuel combustion in stationary sources (like boilers, furnaces, incinerators, torches, etc.),
- other industrial installations (process equipment, ore roasting, chemical processing, paper production, etc.),
- traffic.

25. Stationary combustion installations are in fact estimated to create between 70 and 90% of total SO_2 and particulate emissions. Moreover, they contribute about 50% of total NO_x emissions, a further 40% being produced by traffic. Traffic is also the main source of carbon monoxide (CO) pollution (more than 90%) and a very important source of hydrocarbon (HC) emissions (about 50%).

The radioactive gaseous effluents from nuclear power stations and reprocessing plants must be considered in this context although at present they do not in fact make any significant contribution to the total level of radioactivity encountered in the atmosphere.

26. Energy consumption for traffic purposes produces also pollutants which are potentially toxic if they concentrate in the atmosphere above certain levels. At present, for instance about 36,000 tons/year *) of lead are emitted from automobile exhausts within the Member States of the European Communities.

Concerned by lead concentrations which may locally, especially in areas with heavy urban traffic, become hazardous to public health, the Commission services, in collaboration with experts of the Member States, have analyzed the situation and its

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*) Value estimated for 1973, based on a total gasoline consumption of approx. 70 mill.tons, with an average lead content of about 0,55 g/1 and 70% of total lead contained being emitted in the atmosphere.

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possible evolution from the medical and technical side. As a result of this work in December 1973 the Commission sent to the Council a proposal for a directive aiming at a limitation of lead content in gasoline to 0,4 g/l at maximum for premium grade from 1 January, 1976, and at 0,15 g/l at maximum for regular grade from 1 January, 1978. This measure will decrease the total quantity of lead emitted into the atmosphere by motor vehicles to about 28,000 tons/year in 1980 (1) notwithstanding a probable increase in annual gasoline consumption by about 30% compared to 1973.

III.3. Water pollution

27. The major source of thermal discharges into water bodies is from electric power plants. Depending on the type of thermal power plant (fossil fueled or nuclear fueled), an amount of heat equal to 1.2 to 1.9 times that of the electric power produced is discharged through the cooling system, mainly into water bodies, but to some degree also directly into the air. At the moment, no precise knowledge exists of the distribution of thermal discharges among the different sources but one may suppose that about 20 to 30% of total heat discharged into water originates in the other industrial sectors (process heat).

Taking the energy system as a whole, water pollution occurs also from the production, shipping and processing of oil, either accidentally or by intentional discharge (e.g. during extraction, or from the cleaning of oil tanker bilges, or as liquid effluent from refineries).

Coal extraction is known as another source of water pollution because of acid mine drainage and siltation.

Nuclear power stations release, under carefully controlled conditions small amounts of radioactivity with liquid effluents into the water.

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(1) Assuming that about 25% of the total consumption of about 90 million tons of gasoline espected for 1980 will consist of regular grade quality, and that about 70% of total lead contents is emitted by the atmosphere.

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III.4. Solid wastes

28. Solid wastes are produced in large quantities by the burning of solid fuels in power plants, in industrial and domestic combustion installations, in combined district heating and incineration plants.

Mining activities produce locally large quantities of solid wastes, especially in surface-mining of brown coal which transforms and degrades entire regions for - at a minimum - several years.

29. The marked increase in electricity generation capacity, especially from nuclear energy, foreseen for the next decades will produce important amounts of radioactive solid wastes requiring careful disposal. The growing quantities of spent nuclear fuel elements treated in reprocessing facilities yield high-level radioactive waste which is likely to be stored in solidified form under special control to protect the environment (air, water, soil) from radioacrive contamination (1).

III.5. Siting of installations

30. As mentioned above, the siting of installations for production, transformation and transport (e.g. power lines) of energy under its various forms requires increasing attention in order to protect the environment against pollution and nuisances from these installations. The most striking example is the increasing amount of heat discharged from a growing number of power plants, the increase in size of these plants and the accumulation of large generating capacity at the same site (equipped with high chimney and, more and more, with very large cooling towers). These plants will, apart from water and air pollution, raise problems of land-use and will together with the associated overhead transmission lines create aesthetic nuisance.

Similar problems exist for refineries with special emphasis to water and air pollution and to odours.

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(1) The problems specificially connected with the use of nuclear energy are treated in detail in the "Second Indicative Nuclear Program" of the European Communities approved by the Commission on October 10, 1972 (in printing).

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IV. AN APPROACH TO THE EVALUATION OF THE EFFECTS IN VIEW OF ESTABLISHING AIR QUALITY CRITERIA AND NORMES

31. In view of developing criteria and guides for SO_2, suspended particulates and nitrogen oxides, for use within the framework of the Community, the Services of the Commission, with the assistance of national experts and consultants, are reviewing the various criteria documents available at the international and national levels /9, 10, 11, 12, 13, 14 15, 16, 17/. Following the procedure outlined in the "Programme of Action of the European Communities on the Environment" /Ref. 78/ emphasis is placed on the WHO technical document 506 "Air quality criteria and guides for urban air pollutants" /Ref. 9/.

32. The Committee "Criteria and Standards" of the Commission in its first examination of the WHO document found in particular that the qualitative and quantitative description of the effects of sulphur dioxide and suspended particulates, as given in Table I and in the accompanying text of the document, while most probably still in agreement with the more recent findings, have to be completed and amplified by other results about the character, degree and extension of the effects caused by these pollutants and that indications should be given about the risks related to exposures different from those reproduced in the WHO document (in particular concentration and time dependance). This work is currently underway.

On nitrogen oxides the data available at the time of the preparation of the WHO document (1971) were not sufficient to reach clear conclusions regarding the effects. The Services of the Commission are currently compiling and analysing the recent studies which have been published in order to establish for these pollutants exposure-effect relationships.(*)

33. In a number of countries around the world there exist either air quality standards incorporated in legislation or recommended objectives; the WHO technical document 506 indicates also short-term and long-term goals regarding maximal air pollution levels.

In many cases the mathematical basis and the reference analytical methods used are sufficiently different for a direct comparison between the existing legislations and proposals not to be possible. The Services of the Commission are currently undertaking a harmonization programme for the various analytical techniques and will make recommendations, based on the exposure-effect relationships, as to the most adequate mathematical formulation regarding the expression of the air pollution levels.

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(*) By the way the Commission has started research in this field in the frame of the environmental research programme.

V. POSSIBLE EVOLUTION OF SPECIFIC POLLUTION PROBLEMS

34. Based on forecasts (see chapter II) of energy demand and the share of different energy sources in total demand, this chapter gives a brief analysis of the magnitude of the pollution involved. On the basis of different hypotheses concerning growth of energy demand in its various forms, estimates are made for the quantity of SO_2, particulate matter, NO_x and thermal discharges which are likely to be produced by the main sources of those pollutants; power plants, large industrial plants, domestic heating installations and traffic.

35. A detailed study of air pollution from fuel combustion in stationary sources has been launched by OECD and completed in 1973 /Ref. 78/. On the basis of estimates made by national experts, emissions of SO_2, particulate matter and NO_x originating from these installations and their possible evolution up to 1980 have been evaluated for the principal sectors using fossil fuels. This study revealed the stillimportant role which oil products are likely to play as fuel in the next decade within the 9 EC-Member States. The recent oil supply crisis, however, will certainly change this situation in the sense of a slow-down of the growth-rate of oil products as compared to other fossil energy sources.

V.1. Sulphur dioxide

36. The Services of the Commission, with a group of national experts, have recently reviewed the SO_2 ground level concentrations measured in the years 1971/72 within the Member States /Ref. 20/. The study shows that SO_2 measurements are made in all urban areas, but often, due to the location of the sampling sites and to differences in analytical techniques, direct comparison of results is not possible.

The only definite conclusion is that the annual mean concentrations for the residential sites reported range from about 10 to 300 micrograms/m^3, the highest levels being found usually in large urban areas. Maximal daily values were in general 4 to 5 times the annual mean and the winter to summer ratios lay between 2 and 4. The higher winter values often seem to result the combination of increased fuel demand and adverse meteorological conditions.

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In a number of urban areas within the European Community the observed annual means are significantly higher than the levels used currently as guidance for action in several countries around the world.

In view of these high levels, and while awaiting the recommendations which will be forthcoming at the Community level regarding the criteria and guides, a decrease in the current SO_2 emissions is advisable.

37. According to the OECD report /Ref. 19/ an increase of about 50% in SO_2 emissions from stationary combustion sources has to be expected between 1968 (the base of the study) and 1980 if no counter measures are taken.

In absolute numbers these SO_2 emissions are likely to pass from 14 million tons in 1968 to some 21 million tons in 1980 for the 9 EC Member States. If, because of future difficulties in supply, the share of oil is somewhat lower than assumed one may anticipate that coal consumption will not decrease as rapidly as foreseen by the OECD report. If one factor tends to counterbalance the other, the level of SO_2 emissions expected in 1980 may be more or less unchanged.

Though there are certain gaps in the information which EC Member States were able to give to OECD on the expected repartition in 1980 between solid, liquid and gaseous fuels, existing data indicate that more than 50% of total consumption of stationary combustion sources in 1980 may be accounted for by liquid fuels and another 20% at least by gas. Taking into account the sulphur content of the three types of fuel it follows that the combustion of oil will constitute the major source of SO_2 in 1980, as far as stationary combustion sources are concerned.

38. Bearing in mind the decisive role played by liquid fuels, the Commission services have investigated /Ref. 21/ the possible evolution of the oil supply structure and its average sulphur content. This investigation (see Annex II) provides a starting point for the activities aimed at the abatement of SO_2 pollution within the EC Member States. (This task of abating SO_2 pollution appears as a priority item in the "Programme of Action of the European Communities on the Environment" /Ref. 18/).

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39. During refining operations the sulphur contained in crude oil is mainly concentrated in the heavy fractions (residual fuel-oil(*)) whereas the lighter ones (gasoline, gasoil and kerosene) contain much less sulphur (in general below 1%). This tight relationship between the sulphur content of crude oil and the sulphur content of the residual fuel-oils derived from crude makes it possible to construct an hypothesis for SO_2 emissions based on an estimate of the future supply structure for crude.

On the basis of the supposed scheme (Annex II, tables 4 to 7), which considers the availability of different types of crude as of September 1973, just before the recent crisis, the total sulphur quantity contained in the residual fuel-oil produced from these crudes may evolve as indicated in the following table 4 and may give rise to the SO_2 emissions listed in the last column assuming that 80% of the sulphur contained in residual fuel-oils is emitted and no abatement measures be taken.

Table 4 : ESTIMATED EVOLUTION OF SULPHUR CONTAINED IN RESIDUAL FUEL-OILS TO BE CONSUMED WITHIN EC-MEMBER STATES AND POSSIBLE SO_2 EMISSIONS FROM THESE FUELS.

Year	Total sulphur content*) (million tons of sulphur)	% increase within period of	Total SO_2 emissions (millions tons SO_2)
1971	3.4	-	5.4
1975	9.3	174	14.9
1980	10.8	16	17.3

40) Within large urban areas SO_2 ground level concentrations are known to be strongly dependent upon the amount of emissions at low level (e.g. above all those originating in domestic heating and from small commercial installations fuelled mainly with gas-oil). Within the past decade the consumption of gas-oils for domestic heating purposes has increased very sharply in replacing coal. This trend is likely to continue in the near future although at somewhat smaller growth rates (higher costs of oil products, competition of natural gas and of electricity heating).

(*) Residual fuel-oil = all residual fractions remaining after the atmospheric distillation process of crude oil.

*) In 1971 the average sulphur content of all crudes imported in the Community was about 2%.

In 1971 SO_2 emissions from the combustion of gas-oil were estimated at maximum at about 1.2 mill. tons within EC Member States. In the absence of any control measures they may - a maximum hypothesis - rise to nearly 1.6 mill. tons in 1980 and worsen the situation in already highly polluted urban areas.

In the light of that situation the Commission has proposed a directive /Ref. 22/ aiming at a limitation and subsequent decrease of sulphur content in gas-oils which are put on the market within Member States.

If this proposal is accepted by the Council and implemented in time the SO_2 emissions to be foreseen by 1980 from gas-oil combustion may well remain near to those of 1971.

41. However, under the hypotheses of the Commission's study /Ref. 21/, SO_2 emissions from the combustion of residual fuel-oils are likely to increase markedly from 5.4 mill. tons (1971) to more than 17 mill. tons (1980) if no abatment measures are taken.

In the light of these numbers it must be concluded that all means suited to abate SO_2 emissions from installations burning residual fuel-oils (mainly large stationary ones) deserve special attention.

V.2. Particulate matter

42. As for SO_2, the major fraction of particulate matter is emitted from stationary combustion installations fueled with hard coal and brown coal; it is composed of fly ash, and of unburnt solid matter. The quantity of particulate matter produced is particularly large in power station or other large boilers where solid fuel is burned finely suspended in the air. The greatest part of it is captured by electrofilters with an overall removal efficiency of about 98%.

The combustion of liquid fuels gives rise to formation of fine particles of unburnt fuel which are partially emitted with the flue gases, partly deposited on the walls and emitted only casually on soot blowing.

43. The OECD study /Ref. 19/ cited above estimates a decrease of about 20% in particulate matter in this decade, mainly due to the swing away from coal and due to improved control technology. This decrease is particularly marked in the domestic sector whose share is expected to come down to about 20% of total particulate matter emitted from stationary combustion sources (after 33% in 1968), mainly because - on the hypothesis of the study - gasoil and natural gas are replacing the use of coal.

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44. The Services of the Commission, with a group of national experts, have recently reviewed the suspended particulate matter (especially for particles which fall within the respirable size range) in ground level concentrations measured in the years 1971/1972 within the Member States /Ref. 23/. The intrinsic differences between the determinations of soiling capacity (smoke) and total weight (suspended particulates) were such as not to allow any comparison.

It may be only stated that the annual mean concentrations of smoke for the urban sites reported range from about 20 to 200 micrograms/m^3, with the maximal daily values on the average 5 to 6 times the annual mean values. For suspended particulate matter the concentrations ranged from 70 to 230 micrograms/m^3, with the maximal daily values on the average 2 to 3 times the annual mean values. For both smoke and suspended particulates, winter to summer ratios were around 1.5 to 2.

45. In a number of urban areas in the European Community the observed values are significantly higher than the levels used currently as guidance for action in several countries around the world, and this in spite of the downward trend in levels which has been observed for more than a decade.

In view of this situation, and while awaiting the recommendations which will be forthcoming at the Community level regarding the criteria and guides, all efforts should be made to insure the continuation of this downward trend.

V.3. Nitrogen oxides (NOx)

46. It is known that without the presence of nitrogen oxides in the atmosphere no photo-oxidation of hydrocarbons would occur and the development of photochemical oxidants would be much reduced. Sufficiently reduced levels of either NO_x or hydrocarbons alone in the air tend to alleviate the formation of photochemical oxidants, but the exact relationships are extremely complex and not yet well understood.

Studies have shown that nitrogen dioxide may be associated with increased incidences of respiratory infections in children, with damage to vegetation and with corrosion of electronic components.

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47. Nitrogen oxides are formed mainly during high-temperature combustion of fossil fuels in fixed as well as in mobile installations. Recent estimates indicate that the emission levels will increase at about the same rate as fuel consumption, since there are no adequate control techniques now applied on a large scale for these compounds.

Emission factors (weight of NO_x formed per unit weight of fuel consumed) vary considerably, not only with type of fuel and type of combustion unit, but also between apparently identical units burning the same fuel. Quoted emission factors can therefore only be average or typical values, and considerable variation is to be expected, depending on the mode of operation. This is particularly true of mobile sources, where engine load conditions are constantly changing.

48. A study has been completed recently under contract /Ref.24/ for the Commission's services (see Annex III) aiming at an assessment of nitrogen oxide emissions from energy production within EC Member States for the period 1970 until 1985, together with the possible abatement techniques and associated costs, taking into consideration existing studies and energy consumption forecasts.

Starting from weighted emission factors together with estimated fuel consumption in various sectors, it is concluded that the total NO_x emissions in 1970 within the EC Member States amounted to approximately 7.6 mill. tons. On the basis of the predicted fuel growth pattern used in the study, and assuming no controls, the total NO_x emissions are expected to rise to around 13 mill. tons in 1985.

49. Analysis by sector of fuel use shows (table 5) that in 1970 general industry accounted for one third of the emissions, but transportation is the fastest growing sector and is expected to take over one third of total NO_x emissions in 1985. Thus emissions from transport would double from 2.2 mill. tons in 1970 to 4.5 mill. tons in 1985, by which time it could replace industry as the largest source of nitrogen oxides.

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TABLE 5 : NO_x EMISSIONS: SECTOR BREAKDOWN 1970 TO 1985 (MEAN VALUES)

Year / Sector	1970		1980		1985	
	M Tons NO_x	%	M Tons NO_x	%	M Tons NO_x	%
Electricity Generation	2.1	28	3.1	28	3.5	27
Domestic	0.8	10	1.1	10	1.2	9
Industry	2.5	33	3.3	30	3.8	29
Transportation	2.2	29	3.6	32	4.5	35
T O T A L	7.6	100	11.1	100	13.0	100

.../...

50. The report stresses the large uncertainties affecting the estimates; the main difficulties being: variation in the values of NO_x emission factors used, and finally variations in assumed pattern of fuel consumption. Consequently the true value of sectoral and fuel type emissions probably lie between 0.7 and 1.5 times the indicated figures, while the true total emissions probably lie between 0.8 and 1.2 times the indicated figures (2б limits).

The possible variations in fuel consumption pattern are very difficult to define, for two reasons:

- the consumption in each sector and for each fuel type are not independent, but are related in a complex manner;

- the consumption of each type of fuel is dependent ultimately on the price structure and availability, and also on the rate of growth of the economy of the Community. The current crisis affecting oil supplies will of course have a profound effect on any future estimates.

51. The Services of the Commission, with a group of national experts, have recently reviewed the NO, NO_2, and NO_x ground level measurements carried out in 1971/1972 in Member States /Ref. 25/. Until now relatively few efforts have been made to measure these pollutants systematically. Furthermore, due to the variations in concentration with the exact siting and to the incompatibility of a number of analytical techniques, no comparison between the few results available can be made, and numerical indications of concentration ranges would not be significant.

Efforts are currently being made at the Community level to develop criteria for the siting of sampling stations and for the harmonization of the analytical methods.

In the few instances where trend analyses are available, upward trends seem to be observed, showing the need to develop rapidly a harmonized set of stations within the European Community, generating concentration results upon which decisions can be made.

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V.4. Thermal discharges

52. Concern over the environmental effects of the discharge of heat into natural bodies of water is steadily mounting. An increase in the natural temperature of lakes and streams is reported to affect the growth rate and, in some cases, the species of aquatic flora and fauna /Ref. 26/. Evidence indicates that at some locations certain forms of aquatic life have benefited by increased water temperatures and that this water, used in irrigation, could help promote plant growth. In general, however, the ecological effects of increased temperature are considered detrimental, and opposition to increasing water temperatures is growing.

The solubility of oxygen in water decreases continuously as temperature goes up. On the other hand, the oxygen demand for the biological degradation processes of organic pollutants carried within the water increases with temperature, because these processes are generally accelerated by higher temperatures. Thus, discharge of heat into rivers, raising the water temperature well above its natural level, is detrimental and may indanger this natural resource and aquatic life, especially if the body is already heavily polluted by organic and inorganic matte

For these reasons numerous Member States have set limits for the maximum rise of temperature above natural levels that is to be allowed for water bodies.

53. The main source of thermal discharges is electricity production; the actual share of 70 to 80% of total discharges is likely to increase in the future (see chapter II), unless some economic means of utilizing the vast quantities of waste heat now discharged into the cooling system can be rapidly developed. In order to assess the magnitude of thermal discharges from electricity production and the associated siting problems for power plants, the Commission's services have recently evaluated /Ref. 27/ the possible growth potential of electric energy production within EC Member States (see Annex IV). Two hypotheses are considered:

- the first one to be considered as conservative, assumes that demand for electricity will continue to grow, until to the end of this century, at the same rate as the last 25 years; however, with a progressive tendency to a saturation;

.../...

- the second one to be considered as an upper limit not likely to be reached, assumes that the cost increases of liquid fuels and the short supply of these fuels may continue for some years and will initiate a progressive change in the structure of energy demand within the 3 main sectors of electricity consumption: industry, domestic sector and transport, leading to a sharp increase in electricity demand.

54. The following table 6 shows, for both hypotheses, the evolution of electricity produced from thermal power plants (fossil and nuclear fueled) and the heat discharged into the environment (water and air).

The values given on the basis of two hypotheses do not correspond to the forecasts of the EC Commission. Owing to recent events on the energy market these forecasts are under review.

As liquid fuels will probably be available at sufficient quantities, although their price will be considerably higher, the real situation is likely to occur between the two assumptions.

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TABLE 6 : GROWTH OF ELECTRIC POWER PRODUCTION AND THERMAL DISCHARGES WITHIN EC MEMBER STATES

Hypothesis I

Y e a r	1970	1975	1980	1985	1990	1995	2000
Total gross production (TWh) (*)	855	1,200	1,680	2,350	3,200	4,225	5,400
Yearly mean growth rate (%) within 5 year period		7.0	7.0	6.9	6.4	5.7	5.0
Gross production from thermal plants (TWh)	731.6	1,066	1,534	2,194	3,032	4,045	5,210
Total thermal discharges (TWh)	1,024	1,533	2,267	3,384	4,815	6,624	8,769

Hypothesis II

Y e a r	1970	1975	1980	1985	1990	1995	2000
Total gross production (TWh)	855	1,230	1,800	2,800	5,100	9,000	14,000
Yearly mean growth rate (%) within 5 year period		7.5	7.9	9.2	12.7	12.0	9.2
Gross production from thermal plants (TWh)	731,6	1,095	1,650	2,630	4,910	8,800	13,800
Total thermal discharges (TWh)	1,024	1,579	2,460	4,217	8,583	16,053	25,18[illegible]

(*) 1 TWh = 10^6 Megawatthours (= 860,000,000,000 Kcal)

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55. Even under conservative assumptions (hypothesis I) the quantity of heat discharged from electricity production is likely to increase by a factor of 3 at least from 1970 to 1985 and once again by a factor of 2.6 till to the end of the century (*).

One main conclusion can be drawn from this situation in view of the still increasing rate of pollution of running surface waters within the EC, which is not likely to be reversed before the 80's: it is no longer possible to install new large power plants equipped with cheap open cooling circuits along most of the rivers of EC Member States.

56. The objective of hypothesis II is to show the possible repercussions on the environment resulting from a massive increase in electricity production which could possibly result from high cost escalation of oil products. If in this extreme case thermal discharges from power plants do not present insoluble problems for the protection of the environment one can resumably assume that solutions can be found for reality.

Under hypothesis II assuming a rather unlikely maximum increase in demand for electricity it appears that at least until 1980 the situation will not differ sensibly from that resulting from hypothesis I. Only from 1985 onwards the increase of thermal discharges under the second hypothesis will be sensibly higher than under the first one, and this accelerates till to the end of the century. Thus from 1970 to 1985 thermal discharges will increase by a factor of about 4 and from 1985 to 2000 once again by a factor of about 6.

The conclusion to be drawn from that situation is of great importance for environmental protection and for the land use:

- in spite of the introduction of wet, or of rather expensive, dry cooling towers an ever increasing number of new power plants is likely to be installed at the sea shores, mainly towards the last two decades of the century. The problems of choosing appropriate sites for these plants which satisfy not only the environmental requirements and the cooling needs but fit also in an economic manner into existing guides (with respect to the centres of electricity demand) may become as important as that of developing efficient control methods allowing to decrease the pollutions from these plants.

(*) Assumption is made that from 1985 onwards nuclear power plants of the HTR and FBR type with high steam cycle efficiency are progressively introduced, and that in 2000 these plants deliver 1/3 of total nuclear electricity production (extimated then about 3,500 TWh=67% of total electricity produced from thermal plants).

VI. CONTROL METHODS, PROBLEMS AND CONSEQUENCES RELATED TO THEIR INTRODUCTION (IN THE LIGHT OF ENVIRONMENTAL EFFECTS, OF ECONOMICS AND OF ENERGY CONSUMPTION AND SUPPLY)

57. The most efficient pollution abatement method is a decrease in energy utilization itself or, at least, in the rate of growth of energy production. This will affect not only the emission of pollutants; it will also have system-wide implications (i.e. at all steps from the point of extraction to the point of final use). Any measures which are taken to conserve the use of energy resources or to achieve a better utilization of existing resources must be considered as environmental measures (in addition to their economic importance) insofar as they help to reduce the overall impact of energy on the environment. Thus efforts to reduce energy losses, e.g. by the thermal insolation of buildings, or by improving the efficiency of industrial and domestic apparatus, are indirectly as well as directly of great importance for the fight against pollution. Similarly, a more rational use of energy within the transport sector - e.g. a greater emphasis on collective (buses and trains) means of transport as opposed to cars - will have indirect as well as direct benefits for the environment.

58. Another important pollution abatement relates to the organization of production and distribution within the energy sector itself. Should energy production within stationary installations be centralised as much as possible (better efficiency, pollution control easier to apply and with lower unit cost) or should it be spread out near to the places of final use (less transportation losses, better dispersion of unavoidable pollutant emissions). In the past this question has often been decided upon purely economic grounds (e.g. siting of power plants within the existing grid, choice of fuel for domestic heating installations and for large industrial installations).

These requirements of course must be carefully evaluated in the overall context of long-term planning. Here again a balance between environmental and other goals must be struck.

These broad questions cannot be considered in detail in this first report. This chapter is therefore limited to a short description of the controls which are likely to decrease or abate pollutions riginating from energy production, transformation and use, with special emphasis on SO_2, particulate matter, NO_x and thermal discharges.

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VI.1. Sulphur dioxide

59. In urban areas with a high percentage of sources emitting at low level (like domestic heating installations) a substantial improvement of air quality in terms of SO_2 and particulate matter concentration can be acchieved by decreasing these emissions. This can be done by:

- changing to less polluting fuels,
- limiting the sulphur content of fuels used,
- introducing more district heating.

The first possibility is already well proven, when in the '50s and '60s coal fired heating installations in the Greater London area were converted more and more to natural gas and liquid fuel or to electric heating, resulting in an important decrease of SO_2 and smoke concentration.

60. For reasons of comfort in many Member States a shift towards increased use of liquid fuels (especially gas-oils) and natural gas for domestic heating purposes has taken place. With respect to SO_2 pollution from combustion of these fuels two problems are encountered:

- firstly to assure the availability of sufficient quantities of natural gas (which in general contains very little sulphur) and eventually a preferential allocation to the domestic sector,
- secondly to introduce large scale desulphurisation of gas-oils to levels likely to result in a substantial improvement of SO_2 ground level contentration in urban areas.

With increased introduction of electric heating or district heating systems the SO_2 pollution problem is shifted to the power plant where it is likely to be solved more easily.

61. For large stationary combustion installations such as power plants, large industrial installations and district heating plants the problems caused by the air pollution from SO_2 emissions are at the moment handled in different ways, either by choice of low sulphur fossil fuels (like natural gas or low sulphur fuel-oils), by desulphurisation of flue gases or by appropriate dispersion of emissions with high stacks.

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All these solutions give rise to problems:

The large scale use of low sulphur fuels is either limited by short supply (this is the case with natural and with low sulphur residual fuel-oils) or by the availability of desulphurised fuel-oil and its high cost (*) (Fuel-oil desulphurisation plants have to be constructed in the Member States; high investment costs and increased consumption of crude oil are the main disadvantages).

62. The desulphurisation of flue gases is not yet industrially proven on a scale suitable for large plants. Several processes give rise to products which are water soluble and thus transpose the problem of air pollution into one of water pollution. Moreover, for reasons of space, most of the processes cannot be fitted into existing installations. For lack of operating experience cost estimates given are scarcely valid under industrial conditions and may in reality prove much higher.

Marketing of the extracted sulphur can decrease the costs of desulphurisation, but the demand for sulphuric acid or elementary sulphur may be insufficient to absorb all extracted sulphur. In this case the surplus has to be stored which is economically feasible only with elementary sulphur, thus ruling out those desulphurisation processes which yield other sulphurous compounds. In any case, the problems of creating central storage or disposal places and of organising transport remain to be solved.

63. At the present state of knowledge it seems that neither fuel desulphurisation nor flue gas treatment present significant differences in terms of cost per ton of sulphur extracted. However, if supply difficulties and cost increases for liquid fuels persist for a longer time, the development and introduction of flue gas desulphurisation may become more interesting than the former method. It can be applied in principle to all types of stationary installations and saves more than 7% of crude oil needs otherwise consumed by the desulphurisation process.

64. The technique of dispersing emissions by using high stacks seems to be the least costly method. It is applied in some Member States but not yet generally accepted as a definite solution to the problem of SO_2

(*) A study of the costs of residue and gas-oil desulphurisation has been made in 1972 by STITCHING CONCAWE for the Commission of the European Communities (published as CONCAWE Report No. 13/72). In this report the cost range for the desulphurisation of residual fuel-oil has been indicated as being between 4 and 12 $/ton (cost estimates are related to 1972 conditions!).

pollution. Although emissions into the atmosphere at greater height (several hundred meters) are normally well diluted they may, under adverse meteorogical conditions, be deposited near the source and raise the ground level concentration substantially. The residence time of SO_2 is not yet well known nor the rate of transformation into other compounds (x). These high altitude emissions may be transported over long distances and pollute regions which are otherwise rather clean. In this connection, a programme is under way at OECD to investigate the long range transport of pollutants and the problems related to it, such as the influence of meteorological conditions, the acidity of rainfalls caused by SO_2, the rate of elimination and transformation of SO_2 within the atmosphere.

65. In addition to the directive on the sulphur content of gas-oil already mentioned, the Commission's services are currently engaged, in collaboration with governmental experts, in studying possible other ways of decreasing air pollution by SO_2, the main attention being directed to the sulphur content of residual fuel-oils as the most important contributor to SO_2 pollution.

VI.2. Particulate matter

66. From a technical point of view the problems of abating particulate matter emission from power plants and large industrial boilers have been resolved. A generalized application of existing control techniques also to small stationary combustion installations can further improve the situation, especially in combination with substitution of solid fuels by cleaner ones like natural gas, gas-oil or even electricity applied to combustion installations emitting at low level. Problems of control may arise, particularly as far as concerns the degree to which abatement measures are really respected, or for the preferential allocation of cleaner fuels to small installations.

VI.3. Nitrogen oxides

67. No statutory controls of NO_x emissions are as yet practised either from stationary or mobile sources within EC Member States (x x). The control technology for NO_x emissions is in its infancy, and much proving of techniques under real-life conditions remains to be done.

(x) In the frame of Technical and Scientific Copperation between 19 States the Commission's services participate in work aiming at determining that the transformations which SO_2 undergoes in the atmosphere (Action COST 61 a).

(xx) In the USA the limit set currently for NO_x emissions from mobile sources is 3.1 g/mile (equivalent 14 kg NO_x/t.o.e. for US-vehicles

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For stationary sources, modification of combustion conditions or furnace design appear to hold most promise, and a reduction in NO_x emissions of 50% seems feasible with current technology, as applied to oil and gas-fired plants. Coal-fired plants present problems where control of fuel/air ratio is called for. By using catalysts greater reduction (to about 75%) is theoretically possible but a successful technique remains to be developed. No reliable figures exist on the costs of such control measures.

68. For mobile sources exhaust gas recirculation is already practised on automobiles in the USA reducing NO_x emissions by 50% as compared to 1971 level. Further reduction could be achieved by catalytic means but a successful practical device has not yet been produced. However, an increased introduction of other than conventional types of internal combustion engines, with lower NO_x emission levels, may constitute alternative solutions to exhaust gas treatment devices. Nevertheless, these engines also present problems in terms of CO- and HC- emissions and of increased fuel consumption.

69. The ultimate answer to NO_x (and other) pollution from mobile sources may be to change the propulsion unit entirely - perhaps to an electric drive or to fuel cells - but, at the present state of knowledge, with a penalty to overall fuel usage efficiency.

The original US limit of 0.4 g NO_x/mile set for 1976 will probably only be achieved in a conventional engine (if at all) by the use of some form of catalytic conversion of the NO_x, most likely reduction to nitrogen. However, a satisfactory catalytic converter has yet to be developed; the problems to be solved include damage by inadvertent overheating, mechanical erosion, poisoning of catalyst from fuel additions such as lead (in fact a lead-free gasoline would be required), and last but not least a penalty on fuel consumption and increased costs. Increases in fuel consumption are estimated to have risen by 3 to 12% in the US to meet the current limit of 3.1 g NO_x/mile (*) over uncontrolled engines /Ref. 28/.

(**) (cont'd) and 28 kg NO_x/t.o.e. for European cars. Initially it was intended to achieve a level of 0,4 g/mile (=1.8 kg NO_x/t.o.e. for US cars and 3.6 kg NO_x/t.o.e. for European cars) by 1976, representing a 90% reduction compared with 1971 level. At the time being 1976 models will be required only to meet an interim standard of 2.0 g/mile (=9 kg NO_x/t.o.e. for US-cars and 18 kg NOx/t.o.e. for US-cars and 18 kg NO_x/t.o.e. for European cars). Current uncontrolled emission rates from European cars average about 16 kg (t.o.e. = metric ton of oil equivalent).

(*) This increase in consumption is also caused, at least to a certain extent, by the restrictions imposed on CO and hydrocarbon emissions.

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VI.4. Thermal discharges

70. It is necessary to examine more closely the environmental problems related first to the introduction of cooling towers and secondly, to those other measures likely to decrease the amount of waste heat discharged.

The large quantities of heat discharged locally by power plants can influence, in Central European latitudes, the physical environment, e.g. prevent rivers from freezing in winter (when open cycle cooling is used), increase local formation of mist and affect the micro-climate (when wet or dry cooling towers dissipate the waste heat into the atmosphere).

71. Wet cooling towers consume a certain quantity of water by evaporation *). This water loss may become the limiting factor to the installation of additional generating capacity equipped with wet towers beside a river because peak electricity demand may well be twice that of normal demand and often occurs at periods of low flow.

Another problem is the space occupied by such towers (2 to 3 towers of about 130 m in height and diameter are actually needed for a 1000 MWe power plant /Ref. 29/ occupying nearly 10 ha) ; because of their dimensions they are difficult to incorporate into the landscape without altering its character.

72. Dry cooling towers avoid the evaporation losses incurred by the wet towers. [illegible] On the other hand, if they are associated with a power plant which operates on the classical steam cycle, they decrease even more than wet towers the overall efficiency of the plant and thus the utilisation of energy resources. The high costs of such towers, which are at an early stage of development for large cooling capacities constitute another handicap which has to be compared with greater flexibility for siting.

73. Heat losses inherent to the thermodynamic cycle of power plants are mainly passed to the condenser of the cooling system (nearly 50 % of total heat input for a fossil fired plant and 65 % for a current LWR nuclear plant), the rest being directly discharged to the atmosphere through the stack an the ventilation system (about 12 % of total heat input for a fossil fired plant and 25 % for the LWR plant).

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*) For instance a power station of 1000 MWe equipped with wet cooling towers withdraws about 0.7 m^3/s (if fossil fueled) and about 1.1 m^3/s (if nuclear fueled) from the water body ; another 0.2 to 0.4 m^3/s is used for cleaning of the cooling towers but ultimately sent back to the water body. Assuming that all thermal discharges from power plants in the year 2000 were to be dissipated by wet cooling towers these towers would evaporate approx. 8 % of the total yearly average flow of all rivers within EEC.

74. The vast quantities of heat rejected without further utilization through the condenser could be lowered substantially by extracting an important volume of steam at a higher temperature level and at higher as condenser preserve. This steam could be used, e.g. for district heating, for effluent water treatment, for sea water desalination, etc.

Of course the electricity output of such a dual-purpose plant would be lower compared to that of an electricity-only plant of equal boiler power, but the overall efficiency of the former, measured in terms of energy utilisation, is higher. Unfortunately, the difficulty of transporting heat efficiently over larger distances, e.g. between a power plant and an urban centre, constitutes at present a serious obstacle to the construction of such plants. Hence, such a plant must actually be sited near the centre where the heat is used, which gives rise to problems of cooling and to those of large quantities of pollutant emissions in densely populated areas.

75. In conclusion, it becomes apparent that the problems of thermal discharges are closely related to those of the siting of large power plants which constitute the overwhelming source of such discharges.

From the point of view of environmental protection it appears that a compromise must be sought, upon siting a plant, between divergent conditions each having its impact on the environment :

- the possibility of cooling with the implications discussed before ;
- the easy access and transportation facilities for fossil fuel supply (and solid waste disposal for coal fired plants) ;
- the possibility ot transporting large quantities of electric energy, supposing that still sufficient land is available for new aerial or underground transmission lines ;
- the necessity to locate the plant as close to the centre of demand as possible in order to minimize transmission losses with in the grid and to reach a high load factor of the plants incorporated in the grid which, in turn, implies that large quantities of pollutants are emitted into the air near to densely populated areas unless appropriate control measures are taken.

VI.5. Pollution and energy efficiency

76. A careful analysis of the overall system of electric energy production and its final use may show that the present problems related to air pollution by SO_2, particulate matter and NO_x within urban areas can be more easily resolved by increased use of electricity, in spite of the problems associated with thermal discharges.

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Because pollution is concentrated at a few carefully chosen sites, pollution control measures can be more easily and efficiently applied, and with lower costs to large installations than to small ones.

On the other hand, an analysis of the same system in terms of optimum use of energy resources may show that, from the point of view of energy conservation, more centralized electricity production and a trend towards the growing use of electricity are less effective than the use of other forms of energy.

This example underlines the necessity to perform overall energy system analyses which can determine the best choice of energy source and optimize the solution in terms of energy utilisation and of environment protection. Obviously the availability and the cost of the different energy sources will play a dicisеve role in this choice.

VII. CONCLUSIONS

77. This first report has mainly concentrated, as the Programme requested, on the environmental problems posed by sulphur dioxide, particulate matter, nitrogen oxides and thermal discharges. Its principal conclusions in respect of each of these pollutants can be summarized as follows :

Sulphur dioxide and particulate matter

78. The urgent need is to reduce the level of sulphur dioxide as well as that of particulates within certain regions of EEC Member States where high concentration of SO_2 and of particulates frequently occurs. The Commission has already sent to the Council a draft directive aiming at reduction in the average sulphur content of gas-oils used for domestic heating and in diesel vehicles. Two qualities of gas-oil are foreseen in 1976, namely 0,8 % sulphur and 0,5 % sulphur. By 1980, the two permitted qualities would contain respectively 0,5 % and 0.3 % sulphur. It is for the moment left to Member States to decide on the zones or regions in which the lower sulphur-content fuel is to be used.

79. It is expected that this measure will already make a significant contribution to the reduction of pollution from SO_2, especially in the areas needing special protection, but by itself it will not be enough. The Commission is therefore proposing measures for dealing with those emissions, and their effects, which arise through the combustion of residual fuel-oils and with other problems. These proposals will cover :

(a) the definition of special zones or protected areas.

It should be possible to establish at EEC level the general criteria for the definition of these special zones or protected areas, while national authorities would themselves be responsible for defining the regions which correspond to the criteria. The Commission is at present in the process of reviewing existing information with a view to

-(i) defining the relevant parameters (e.g. hourly values, 24-hour values, annual means, winter/summer ratios, etc

-(ii) agreeing on goals, whether of a short, medium or long term nature.

(b) the limitation of the sulphur content of the residual fuel-oils burned within the special zones. Exceptions could be permitted for those installations equipped with pollution-control devices which permit emissions to be reduced in a manner equivalent to the use of low sulphur fuel.

.../...

Exceptions could also be made for those installations using high stack dispersion, but this should be seen as a temporary relief (see parag. 82 below). In any case, ground level concentrations should not exceed those which would have been produced by the use of low-sulphur fuel.

(c) maximum sulphur limits for residuel fuel-oils used outside the protected zones, with similar possibilities for exception.

(d) harmonized methods of measuring and monitoring pollution levels.

80. In addition, proposals will be made for the preferential allocation of clean fuels (like natural gas and low sulphur oils) to certain categories of use. It is most desirable to aim at the preferential use of the clean fuels available in each country in those sectors of consumption where other methods of preventing air pollution are not practicable. These sectors include the domestic and commercial fields and also some industrial activities in which large numbers of small consumers emit flue gases near ground level. Control of emissions in these cases can only be achieved through use of clean, low-polluting fuels and good combustions practice. Most Member countries are in favour of encouraging the use of natural gas and petroleum distillates in these sectors, but the total fuel consumption involved is large, and may pose problems of availability of suitable fuels. It also implies a need for investment in fuel distribution services, in particular for natural gas.

81. In the medium-term, greater emphasis must be placed on other control techniques. From the present state of knowledge and experience it seems that neither residual fuel-oil desulphurisation nor flue gas treatment present significant differences in terms of cost per ton of sulphur extracted. However if supply difficulties and cost increases for liquid fuels persist for a longer time, the development and introduction of flue gas desulphurisation (FGD) may become more promising than the former method. FGD can be applied in principle to all types of new stationary installations burning solid, liquid or gaseous fuels and saves more than 7 % of crude oil, which would otherwise be consumed by the fuel-oil desulphurisation process.

That is why an effort to promote the rapid development and introduction on an industrial scale of flue gas desulphurisation process is needed with in EEC Member States, especially for large stationary combustion installations which would become more flexible in terms of fuel supply and of siting requirements.

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For reasons of operating reliability of such FGD-units, large industrial installations and power plants which plan to use this technique should be equipped also with high stacks which assure at least a certain dispersion of the emitted flue gases in case of failure of the FGD-unit (thus avoiding a plant shutdown).

82. From the point of environmental protection it is not acceptable to transport pollution over long distances into less polluted areas. For this reason the dispersion technique of pollutant, making use of high stacks alone must be regarded with caution, unless there is sufficient evidence that the transport of sulphur dioxide and nitrogen oxides is not nuisance in itself and that their transformation in the atmosphere does not give rise to the formation of other harmful compounds, and that they are quickly eliminated from the atmosphere.
Even when pollution problems do arise, the dispersion technique could be accepted at least as a short term method of relief, provided that the later addition of a flue gas desulphurisation unit is required as soon as these installations are at hand.

The Commission will make proposals both as regards the introduction of flue-gas desulphurization and conditions for the use of high stacks, once the discussions to be held on this report are concluded.

83. The following table 7 gives a tentative (not xhaustive) indication of the types of solutions which must be considered and which in the light of present knowledge are likely to relieve in the short-term and to solve in the long-term the SO_2 problem.

Although the multitude of solutions proposed at table 7 may appear confusing at first sight, the underlying approach is simple : to deal with the problems in different forms for different regions, for different sources and for different time-scales.

Table 7

Solutions for decreasing SO_2 emissions originating from stationary combustion sources

Source location / Type of source	High pollution areas: Urban areas with industrial predominance	High pollution areas: Urban areas with residential predominance	Low pollution areas: Non-urban areas with small population density, rural predominance
- Power plants	High sulphur fuels only with high-stacks and FGD (1) Low sulphur fuel-oils in special situations		High sulphur fuels only with high stacks and FGD. Low sulphur fuel-oils in special situations
- Large industrial and other installations	High sulphur fuels only with FGD and high stacks. Urban sulphur fuel-oils in special situations	Low sulphur fuel-oils in general	High sulphur fuels only with high stacks and FGD low sulphur fuel-oils in special situations
- Small industrial installations	Low sulphur fuel-oils Natural gas for heat production		Low or medium sulphur fuel-oil
- Domestic and artisanal installations	Change to natural gas for heating purposes Gas-oil Type A (low sulphur) Introduction of district heating Improved technology (e.g. heat pump, better insulation of buildings)		Gas-oil Type B (higher sulphur content)
- Power plants	Mainly nuclear plants FGD with high stacks ; low sulphur fuel oils ; new technology		Mainly nuclear plants FGD with high stacks ; low sulphur fuel-oils ; new technology
- Large industrial and other installations	Low sulphur fuel-oils FGD together with high stacks for high sulphur fuels ; new technology (e.g. gasification)		Low sulphur fuel-oils FGD ; new technology (e.g. gasification)
- Small industrial installations	Natural gas for heat production New technology (e.g. fluidized bed combustion)		Low sulphur fuel-oils ; new technology (e.f. fluidized bed combustion)
- Domestic and artisanal installations	Natural gas for heating Gas-oil Type A; Large scale district heating; improved and new technology (e.g. heat pump, [illegible] of buildings)		Natural gas Gas-oil Type A; Improved and new technology.

[illegible]

84. Nitrogen oxides

The expected large increase in the emission of nitrogen oxides from stationary fuel combustion sources as well as from mobile sources and the lack of developed and widely applied abatement techniques for these substances lead to an urgent need for national authorities to examine the air pollution problem of nitrogen oxides in their countries. The lack of knowledge concerning both emission and occurence of nitrogen oxides, their effects on health, vegetation, etc. and their close relationship with formation of oxidants and smog conditions raise a number of important questions.
The Commission has begun a programme of research on the subject.

85. The field of control technology for nitrogen oxides requires assessment. There is only very limited experience in applications of nitrogen oxide control techniques to fixed combustion installations whereas for mobile sources the extensive use of diesel engines could improve the NO_x emissions (as well as other pollutants) coming from motor vehicles.

The present prospects for control of nitrogen oxides depend on the development and implementation of improved combustion techniques.

While waiting for an improvement of knowledge in this field, certain precautionary measures, in respect of both stationary and mobile sources of NO_x, could be taken.

86. Thermal discharges

Power plants constitute the most important source of thermal discharges. In the light of present technology this situation is not likely to change much within the next decade, whereas electricity production will certainly continue to grow at a similar rates as in the past decade, i.e. a doubling of the production in about 10 years. The growth rates of later decades till to the end of this century are open to speculation but they are unlikely to fall below 5 %.

As a consequence the total quantity of heat discharged directly into the environment by power plants may increase by at least a factor of 8 in the year 2000 as compared to the situation in 1970, even if it may be lowered by improved technology and other uses of waste heat.

87. Already within this decade in most Member States the cooling capacity of inland surface waters will be exhausted if the open cycle cooling technique mainly used hitherto is not substituted by the introduction, on a large scale, of wet cooling towers. The Commission will make proposals to this effect.

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88. With increasing unit size of power plants and with trend to installing multiple units at a given site limits to the generalized use of wet cooling towers are imposed by the large quantities of water evaporated in the towers (effect on the microclimate) and by the water withdrawn from the rivers. If for instance the total evaporation from wet towers were limited to 2 % of the average annual flow of European rivers, and to 10 % of the flow in periods of low water coinciding with high electricity production, it would not be possible to evacuate more that 5000 TWh of waste heat per year by these wet towers. Under this hypothesis some of the EEC Member States would be confronted from the nineties on with the need to look for other methods of evacuation of waste heat from electric power production.

89. This situation can be matched in different ways, each of them presenting problems with regard to environmental protection, to the rational use of natural resources, to the economy of energy production, transportation and use and to the development of regional activities :

- by the installation of power plants equipped with dry cooling towers where the waste heat is discharged directly to the atmosphere ;

- by the location of new multiple unit power plants at the sea shores where eventually a cheap open cooling circuit can be used ;

- by the decentralization of power production in smaller plants which are equipped with dry cooling towers and the devices required for compliance with emission limits set for air pollutants, which are located near to large urban areas, and which may use the waste heat for district heating and other purposes.

90. At the present stage of knowledge a through investigation of the problem related to thermal discharges must be undertaken. The studies must be directed towards :

- an establishing of plans with regard to the thermal dischardes which can be directed to rivers, and especially to coastal waters, without damaging the ecosystems,

- an increased development of dry cooling towers through appropriate measures such as R and D contracts, exchange of information and experience.

In parallel to these studies guidelines are to be elaborated facilitating the siting of new power plants at carefully chosen places in consideration of the requirements of environmental protection.

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These guidelines should take into account not only environmental and economic considerations but also give thought to the most efficient use of natural resources in terms of energy consumption, land use, water use.

The Commission will facilitate the exchange of information between Member States in respect of both siting plans and technology and will prepare guidelines for discussion.

The wider issue

91. The discussion of the environmental impacts related to energy production transformation and use has been limited to a few topics falling within the scope of this report : sulphur dioxide, particulate matter, nitrogen oxides and thermal discharges. The problems raised at present by these pollutants are considered in the most urgent need for solution, mainly because of the magnitudes which emissions of these pollutants are likely to reach the near future if nothing is done.

92. In a wider sense, the most effective pollution abatement method would be in fact a decrease in the rate of growth of energy production accompanied by a better utilization of existing resources and by improved technology. This would not only affect the emission of pollutants and decrease problems created by the availability of fuels also have system-wide implications (i.e. at all steps from the point of extraction to the point of final use). Thus the efforts to reduce energy losses (i.e. by improving the efficiency of processes and apparatuses or by better thermal insulation of buildings) would decrease the overall impact of energy on the environment and would be indirectly as well as directly of great importance in the fight against pollution.

93. The approach to efficient abatement of pollution coming from energy production, transformation, transport and use cannot be a partial one concentrating on isolated installations or plants. With a view to the long-term goal it is necessary to assess all environmental effects caused by complete energy systems, permitting solutions which, upon comparison with other available systems, may yield the optimum long-term approach. This implies the choice of using the most appropriate energy form at the right place, not only on the grounds of economics but also in terms of energy conservation and environmental protection.

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ANNEX I

Summary of the actions foreseen in this field by the Programme of action of the European Communities on the environment

The programme of action on the environment specifies in its part II, title I, chapter 5, section 2, the actions relating to energy production. A summary is made there of the problems of pollution and nuisances related to the energy production, in particular :

- atmospheric pollution caused by the combustion of fuels in fixed plant and refineries, domestic heating and internal combustion engines,
- water pollution caused by the discharge of cooling water and pollutants,
- thermal pollution of water and air by electricity generating stations.

The Programme envisage that the Commission will :

- examine the various forms of pollution and nuisances in question, their concentration in the areas in question, the damage they cause and their related costs,
- examine the methods at present in use to combat these forms of pollution and nuisance, their effectiveness, their cost and also the desirability of undertaking research with a view to improving these methods,
- study all appropriate measures to reduce the concentration of these forms of pollution and nuisance to an acceptable level, while taking into account the requirements of different regions,
- work out the cost of all these measures and relate it to that of the damage caused,
- define, in the form of options with their estimated costs, measures

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for reducing the intensity of these forms of pollution and nuisance to an acceptable level.

This work, and other work on estimates of costs of measures which do not concern the protection of the environment, will form the basis for the decisions to be taken on fuel policy.

In submitting the results of this work to the Council with a view to adapting the decisions taken in energy policy, it should be possible not only to point out the economic and technical results of the various measures which could be taken, but also to concentrate attention on the consequences that these measures might have on the siting of fixed plant; this particularly concerns the siting of new power stations, refineries and plants for reprocessing nuclear fuels.

As far as the procedure and the timetable are concerned, the Programme indicates :

A preliminary general report on the problems of pollution and nuisances relating to energy production and particularly on thermal pollution, SO_2 (in connection with particles in suspension) and NO_x will be drawn up, in so far as is possible, before 31 December 1973, for subsequent discussion with national experts.

In the light of these discussions, the Commission will make proposals to the Council as soon as possible, and at the latest by 31 July 1974.

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ANNEXES II-III-IV

THE ANNEXES II-III and IV

WILL BE DIFFUSED LATER

Annexes were not available at the time of scanning.