ISSN 0256-6141

ENERGY IN EUROPE

Energy policies and trends in the European Community

Number 13 May 1989

Commission of the European Communities □ Directorate-General for Energy

Commission of the European Communities

Directorate-General for Energy

ENERGY IN EUROPE

Energy policies and trends in the European Community

Number 13 May 1989

For further information concerning articles or items in this issue please contact:

The Editor
Energy in Europe
DG XVII
Commission of the European Communities
200 rue de la Loi
B-1049 Brussels
Belgium

Telex: COMEU B 21877
Fax: Brussels 235.01.50

Manuscript completed in April 1989

Luxembourg: Office for Official Publications of the European Communities, 1989

Catalogue number: CB-BI-89-001-EN-C

Printed in the FR of Germany

Contents

Introduction 5

Towards a common energy policy in the completed internal market 7

Evaluation of energy technology programmes 12

A — Evaluation of the energy demonstration programme 13

B — Evaluation of the oil and gas technology support scheme 14

European technologies for energy management — Thermie programme 16

The Community coal economy and its prospects 22

Greece — Energy profile 28

Refining industry: A two-speed Europe? 31

Energy prices: statistical analysis of end-consumer prices in the European Community 36

Public opinion in the European Community on energy in 1987 42

An introduction to the greenhouse effect 47

Contribution of nuclear power to the greenhouse effect 53

Hydropower — a new perspective? 55

The role of energy storage in interconnected power systems 59

Transport of radioactive materials within the European Community 63

SER photosystem 70

Community news 72

European Parliament
ECSC Consultative Committee
Joule
Nemex '88
Laws and regulations relating to natural gas
Energy technology project — oil and gas

Document update 78

Abbreviations and symbols

:	no data available
-	nil
0	figure less than half the unit used
kg oe	kilogram of oil equivalent (41 860 kjoules NCV/kg)
M	million (10^6)
t	tonne (metric ton)
t = t	tonne for tonne
toe	tonne of oil equivalent (41 860 kjoules NCV/kg)
fob	free on board
cif	cost-insurance-freight
MW	megawatt = 10^3 kWh
kWh	kilowatt hour
GWh	gigawatt hour = 10^6 kWh
J	joule
kJ	kilojoule
TJ	terajoule = 10^9 kJ
NCV	net calorific value
GCV	gross calorific value
ECU	European currency unit. The ECU is a composite monetary unit consisting of a basket of the following amounts of each Community currency:

BFR	3.71	HFL	0.256
DKR	0.219	IRL	0.00871
DM	0.719	LIT	140
DR	1.15	LFR	0.14
FF	1.31	UKL	0.0878

USD	US dollar
EUR 10	Total of member countries of the EC before accession of Spain and Portugal in 1986
EUR 12	Total of member countries of the EC
I or —	discontinuity in series
of which	the words 'of which' indicate the presence of all the subdivisions of the total
among which	the words 'among which' indicate the presence of certain subdivisions only

Introduction

This issue starts with an article by the Director-General for DG XVII, Mr Constantinos Maniatopoulos, with the title 'Towards a common energy policy'. This reviews the developments up to the present day of the Community's energy policy, including some of the past achievements, and the needs for the future especially in the light of the opening up of the internal market.

At the end of 1989, the Council Regulations covering the Community's two energy technology programmes — energy demonstration and hydrocarbon technology development — expire. These programmes have been the subject of evaluations by outside experts and the reports of these experts are summarized in an article. This leads us on to the new Thermie programme — which has recently been agreed by the Commission as a successor to the two energy technology programmes. The article 'European technologies for energy management' presents the reasons for a new Community initiative in this field and describes the main features of the programme.

The article on the 'Community coal economy and its prospects' is the third in our 'Community supply' series following on from the oil and uranium articles in the last two issues. The article on Greece is also the next in the series describing the energy situation in the Community's Member States.

'Refining in Europe' examines the differences between the refining industries in the north and south of Community and poses the question — do we have a 'two-speed' Europe?

Improving the transparency of energy prices is the subject of a recent Communication from the Commission to the Council. One of the background documents used in the preparation of this Communication was the result of a statistical study of final energy prices paid by Community consumers. The article on energy prices gives details of this study.

The article on 'Public opinion in the European Community' reports on the results of the latest survey in the series to cover energy which was carried out in 1987. When we carried out that survey, it was probably too early for public opinion to have been influenced by the growing concern about the so-called 'greenhouse effect'. The next article in this issue explains what this effect is and why it is important to the energy sector. One of the main references for the article was the paper sent by the Commission to the Environment Council in November 1988. The short article on 'Nuclear power and the greenhouse effect' points out the role nuclear power has played in freezing the emissions of carbon dioxide from the Community's power stations.

Another source of electricity which does not contribute to the greenhouse effect is hydropower. The next two articles cover two particular aspects of this energy source. The first is 'small hydro' and the article describes the Commission's activities in stimulating and supporting its development. The second article describes the use and further potential for 'pumped storage' as a means of storing energy and, in particular, of offsetting the discrepancy between power demand and availability in interconnected systems while contributing to environmental conservation.

The article on the transport of radioactive materials within the European Community is based on the first part of a report prepared by the Special Permanent Working Party for the transport of radioactive substances. It describes the extent of radioactive material transport — well over one million packets shipped within the Community each year, radiation protection and hazards associated with the shipments and the need for specific regulations.

Finally, the short article on the 'SER photosystem' describes the development of a system of stereo-photogrammetric instruments installed and used in a helicopter for checking the structure of offshore equipment and installations. This work was one of the many projects supported by the hydrocarbon technology development programme.

Towards a common energy policy in the completed internal market

C.S. Maniatopoulos — Director-General for Energy

Introduction

Energy policy is never an end in itself: it serves economic policy in general and consumers in particular.

The regular and stable supply of high-quality, convenient, reasonably priced energy is fundamental to the workings and development of both the economy and society. Recent energy crises, the dominance of energy-producing countries on the world scene, the economic and strategic importance of the energy industry, of those manufacturing equipment for it, and employment related to the production and supply of energy, are all factors conditioning national economic policy.

Europe cannot therefore afford to underestimate its dependence on imports despite signs of a short-term abundance of energy.

Energy is still of strategic importance to the economic and social development of our Community. The work of the new Commission will be a major test of its credibility in this sector.

Foundations

The Treaties: two of the European Treaties (ECSC and Euratom) relate specifically to two energy sources, but energy policy, as such, is not touched upon in the EEC Treaty: in the economic context of the 1950s, European coal was still the chief energy source. Europe's founding fathers also believed in the need for R&D in the nuclear energy sector to provide, in the long-term, a substitute energy source for the future.

The market: At the end of the 1960s an abundant supply of cheap, imported oil into a Community which had limited internal energy resources dominated the Community market. It became the chief production factor influencing the competitiveness of the Community's economy: this oil determined 'energy policy'.

The crises which successively hit the supply of energy to Europe led to a recognition of the vulnerability of an energy policy centred on oil, and to the need for a Community energy policy.

Brief recap: 1961 — closure of the Suez Canal; 1967 — the Six-Day War; 1973/74 — the Arab oil embargo; 1979/80 — the fall of the Shah of Iran. At first the need was perceived for short-term emergency measures. This led, most notably, to the creation of an oil reserve.

Consequence: birth of a Community policy. The first principles of Community energy policy, and its chief objectives crystallized in the wake of a succession of energy supply crises. Their implementation demanded a consensus between Member States.

The legal instruments most frequently used were Article 235 EEC for long-term measures, Article 203 EEC for regulations concerning notification and Article 103 for short-term crisis measures. It was only during the Greek Presidency, in the second half of 1983, that the Energy Council defined the role energy policy was to play in the Community. A document on this subject was intended to provide food for thought at the 1983 meeting of the European Council in Athens, which hoped to propose new Community policies. It did not succeed in its objective.

The development of a Community energy policy

The realization that the Community was in an extremely vulnerable position economically, strategically and, therefore, politically prompted the formulation of a Community energy policy within a few years.

This policy has three main props:

— **Community objectives** for about 10 years ahead. These are proposed by the Commission, adopted by the Council and regularly monitored by the Commission.

The first objectives, for 1985, were adopted in 1974. The latest — for 1995 — were adopted by the Council in September 1986.[1]

1 OJ C 241, 25.9.1986.

These objectives — based on the concept of comparable, but not identical, efforts on the part of the Member States — are designed to reduce dependence on oil by reducing energy-intensiveness on the demand side and diversifying supply (nuclear; natural gas; solid fuels; renewables).

This is a genuine long-term strategy based on achieving a balance between market forces and government intervention.

— **Community financial support** for the energy sector in the form of grants and loans. In 1986 this amounted to some ECU 4 billion (between 6% and 7% of the Community's energy investment) of which ECU 1 billion was in the form of grants.

The energy technology programmes of the Commission's Directorate-General for Energy (demonstration; technological development in the oil and gas sector) were introduced in 1973 and 1978 respectively. They will run in their present form until the end of 1989.

— **Common positions and measures** on matters of particular importance.

Two examples come to mind: measures to deal with a supply crisis (oil stocks, required since 1968 and a system of rationing, which has existed since 1977/78) and the general principles adopted by the Council in 1980/81 on **energy pricing policy.**

In the field of external relations the Community has succeeded in persuading other industrialized nations to agree to burden-sharing in relation to the import of petroleum products from the oil-exporting countries. In this connection, mention should be made of the Commission's involvement in the work of the International Energy Agency, alongside its industrial partners.

The Community has also concluded cooperation agreements with the developing countries on energy planning. Regular contact has been established with the members of OPAEC, OPEC, Olade and Asean.

In the nuclear energy field, apart from the very close collaboration with the International Atomic Energy Agency and the OECD/Nuclear Energy Agency, mention should be made of the major agreements between the Community and the USA, Canada and Australia relating to uranium supplies, and the provision of nuclear fuel cycle services.

Some results

The results for the Community as a whole are impressive. Between 1973 and 1986 energy intensiveness was reduced by almost 25%. Energy dependence was reduced from 65% to less than 45%. Oil's share of energy consumption fell from 63% to 47% and that of oil and gas in electricity generation from over 40% to around 15%. In the same period Community energy production rose by over 70%, due mainly to oil (from 10 to 150 Mtoe) and nuclear energy (a sixfold increase, accounting now for one-third of electricity generated and 13% of energy consumed).

The energy situation today is characterized by an abundance of supply which makes the achievement of the 1995 objectives uncertain.

(i) The reduction in energy intensiveness seems to be slowing down: if this is the case, EUR 12 (320 million inhabitants) will probably consume, in 1995, an extra 100 Mtoe, adding, at current prices, ECU 10 billion to the energy bill.

(ii) Such a trend could create further pressure on the oil market, raising the spectre of another oil crisis.

(iii) Solid fuel consumption appears to be declining whereas the 1995 objectives call for it to increase.

(iv) The position of electricity in the year 2000 and beyond is affected by great uncertainty about the future of nuclear energy and by fairly new and pressing environmental constraints, such as acid rain and the greenhouse effect.

It should also be mentioned that in 1986 the Community adopted new rules on State aid to the coal industry and that it met, with considerable resolution, a succession of problems in the nuclear sector: 'Chernobyl' and 'Transnuklear' are all names which speak volumes. The various difficulties encountered in the nuclear sector have brought into focus the role of the Commission in this area, and clarified its responsibilities in the areas of supply, non-proliferation and nuclear safety.

However, despite considerable effort and sometimes spectacular results, it would be hard to describe the energy sector as an example of satisfactory and effective European integration. Institutional obstacles, such as the absence of any free-standing Community energy policy, and structural obstacles, for example the differing degrees of Member States' dependence on imports, might go some way towards explaining this state of affairs.

However, the encouraging results and the aforementioned limits reveal the strategic importance of the sector and the progress still to be made. They also demonstrate the need for a rigorous energy policy.

The challenge ahead

Energy cannot remain isolated from the drive towards 1992 and the single market, marked by the milestones of the 1985 White Paper, the Single European Act and the Council decisions of February 1988.

The principal objective of future Community intervention in the energy sector should be the further development of the internal energy market. The Commission, in cooperation with the other institutions and national governments, should work to foster positive attitudes (attitudes being at present too closely bound to national conceptions of security of supply), to the essential objective of the internal market and the reduced costs to the consumer, resulting from increased trade between Member States; in short to the energy sector's participation in, and active contribution to, the success of the Single Act and the challenge of 1992.

Considerable imagination and creativity will be required to achieve acceptance for the new energy policy priorities in other policy areas.

The Working Document on the Internal Energy Market (COM[88] 238, 2 May 1988)[2] provides the basis for the future labours of the Commission's services.

Much of this work has already been started and it should be completed in the course of 1989.

The new Commission must rise to this challenge

The new Commission faces a difficult task: how can the transition be made from a Community policy to a common energy policy? By 1992 the Commission must establish six priorities:

To define the forecast framework for energy policy

No energy policy can be devised without taking a long-term view. The 1995 Community objectives are the fruit of deliberations on the prospects up to the year 2000.

The Commission departments (DG XVII) are giving priority consideration to the prospects for the energy sector up to 2010 (at world and Community level) and the results of their work should be ready by 1990.

To proceed with caution yet with determination towards the creation of an internal energy market

The completion of the internal energy market is indisputably DG XVII's chief priority.

Certain work should be carried out or continued in an inter-departmental context: in particular the harmonization of quality standards for products and equipment; the opening-up of public procurement and the more rigorous application of the provisions of the EEC Treaty to the energy sector.

Other tasks, such as ensuring the free circulation of energy products within the Community, common carriage, and the consumer's right to opt for the supplier of his choice, will fall entirely within the province of DG XVII. A true common market in nuclear fuels will also have to be maintained.

In this context an effort should be made to facilitate transfrontier cooperation between operators in the market. The development of a European company statute would assist in this.

Any policy proposals to be made should be founded on objective economic analysis of the long-term prospects for maximizing the efficiency of the Community's energy networks and infrastructures, taking into account the social and regional consequences of the necessary restructuring of some energy sectors, such as coal, and concerns

2 See the special edition of *Energy in Europe*.

about safety and public acceptance, which are affecting development in the Community's nuclear industry.

Developing back-up policies for this great enterprise

These must concentrate on three basic aspects which are to a great extent interrelated.

(i) **Economic and social cohesion**
By what means might the role of the structural Funds in further integrating certain more remote Member States into the Community be supplemented?

Discussion in this area should focus on infrastructure, primarily the interlinking of gas and electricity networks, and how to finance it. Special attention should also be paid to the development of local energy sources.

(ii) **Energy technology**
Much imagination will be required to ensure that energy technology is given its rightful place, and to define the role of the Community in this area. The encouragement of technological innovation and its application must be amongst the Commission's top priorities, especially in the energy sector.

The current (demonstration and oil and gas technology) programmes expire at the end of 1989. They should be replaced by a new programme. The main emphasis should be placed on carrying out pilot projects, disseminating innovative technologies, on replicating successful projects and adapting them to regional conditions, and on disseminating information about these projects.

(iii) **Energy and the environment**
The progressive completion of the internal energy market should be accompanied by the parallel development of deeper concern about the need to balance the production, transport and use of energy against the need to protect the environment.

The problems posed by emissions of gases (e.g. SO_2 and NO_X), and particulates (e.g. lead), deforestation, the greenhouse effect (CO_2) and the destruction of the ozone layer should be central to thinking on this subject.

Protection against ionizing radiation, protection against oil slicks, action to combat chemical pollution, and the safety of installations (offshore oil rigs, nuclear power stations, etc.) must continue to receive careful consideration and, if possible, be the subject of appropriate Community programmes. More efficient energy use and the utilization of certain renewable energy sources could also help slow down environmental degradation.

These ongoing and intensive efforts to ensure that energy growth is compatible with environmental protection and public health considerations should gradually bring about a greater convergence of views on the energy policy to be pursued at Community level, including the policy in the areas which are now the subject of the greatest controversy. The effectiveness of future action by the Community will depend in no small measure on the achievement of this objective.

Developing the external relations dimension of the internal energy market

The development of the internal market, and the cohesion of the Community, in the energy sector, demands new initiatives in the Community's external relations policy.

Active participation in the GATT negotiations would seem essential in view of the possible inclusion of energy in the brief of the Working Party on Natural Resources, as would an active presence at the second phase of the EEC/GCC (Gulf States Cooperation Council) trade negotiations. The active promotion of the ecu as a currency for energy transactions should be undertaken in this context, in cooperation with the trading partners concerned.

The establishment of a common trade policy in the sectors of oil (currently excluded from the provisions of Article 113 EEC) and coal (Article 71 ECSC reserves this policy for the Member States) would now seem to be necessary. It is important to bear in mind the ambiguous role of the Community in this area, applying economic sanctions decided in political cooperation. This particularly affects petroleum products, coal and uranium.

Strengthening the social dimension and consultation procedures

As in other areas of Community policy, the completion of the internal energy market should be accompanied by increased consultation with the social partners.

Procedures for consultation with industrialists and their European associations have been operating satisfactorily for several years. It remains only to develop the structures needed to improve consultation with workers' representatives and, in particular, the European Trade Union Confederation. This work is already under way.

The dialogue with the other sectors concerned, such as the consumers' associations (industry, SMEs and domestic users), should also be developed.

Guaranteeing long-term security of supply

The Community will continue to be dependent on imported energy. To ensure the continuity of its supplies in the long term it is necessary, on the demand side, to keep energy consumption under control, and, on the supply side, to ensure adequate diversification of supplies and maintain or even increase indigenous production.

In the case of oil and natural gas, the main imported energy sources, close cooperation must be maintained with the other industrialized countries, especially Japan and the USA, so that all eventualities can be coped with. Guarantees of long-term supplies could be sought from the main producer countries, in particular in the Middle East.

Conclusions

Community energy policy was born out of the oil crises of 1973-74 and 1978-79.

In a less fraught energy situation, which still, however, gives grounds for concern in the long term, it will be the responsibility of the new Commission to make the leap towards a more convergent rather than merely coherent national policies.

This will lead to a genuine common energy policy and so serve to strengthen the unity of the Community in the internal market.

Such a combined approach will enable the attainment of the energy policy's principal objective, which is to serve economic development in general, and the consumer in particular, by guaranteeing the supply of energy at the lowest possible cost.

Experience has taught us that energy should never again put the brake on economic growth, but should rather contribute to the promotion of growth and competitiveness, and hence job creation.

Evaluation of energy technology programmes

The EEC Council Regulations (3639/85 and 3640/85) governing the two Community programmes for the promotion of energy technology — the energy demonstration and the hydrocarbon technology programmes — expire at the end of 1989. The Commission has reviewed the future of these programmes in the light of the new economic prospects created by the unification of the internal market (COM[86] 164 final of 20.3.1989). The programmes have also been assessed by independent experts.

The independent evaluations confirmed that the programmes made a positive contribution towards the achievement of the Community's long-term objectives by, in the case of the energy demonstration programme, stimulating 'a very important amount of activity in the application of innovative technologies' and, in the case of the hydrocarbon programme, by increasing 'the pace of technological innovation in the Community's hydrocarbon sector'. The evaluation reports are not, however, without criticism of the present programmes.

This article summarizes the main points of the evaluation reports. It serves as an introduction to the following article 'European technologies for energy management: Thermie programme' a single programme which will replace the existing two energy technology demonstration programmes at the end of 1989.

The programmes in brief

The *energy demonstration programme* was launched in 1978 and the current phase is covered by a Council Regulation. It is in force from January 1986 to the end of 1989. Up to the end of 1987, the period covered by the evaluation, 1 455 projects had been selected on the basis of more than 5 000 proposals submitted.

The breakdown of these projects by subprogramme is given in Table 1. Overall, 52% of the projects are concerned with renewable energies (solar, wind, geothermal, low-power hydroelectric, biomass and waste), 36% with energy saving in the various sectors of industry, in buildings and in transport, 9% with solid fuels including the technology of liquefaction/gasification, and 3% with electricity.

Table 1

Support for subprogrammes 1978-87

Subprogramme	Number of projects	Total allocated MECU	% of support
Alternative energies	752	240.6	31.5
Energy saving	526	216.5	28.3
Substitution of hydrocarbons	117	113.4	14.9
Liquefaction and gasification	50	193.6	25.3
Total	1 445	764.1	100.0

Source: DG XVII contracts.

With regard to *energy saving, renewable energies* and *electricity* of the 1 322 projects selected (see Table 2):

(i) 330 projects had been completed or were in the final phase so that an evaluation could be carried out;

(ii) 661 projects were in progress;

(iii) 331 projects (25%) had been abandoned.

Table 2

Support for subprogrammes (breakdown)

Subprogramme	Amount allocated (MECU)	Number of projects	Average amount per project (x ECU 1 000)	% of total
Alternative energies				
Biomass	78.5	173	454	16.3
Geothermal	58.9	120	491	12.2
Hydroelectric	21.7	90	241	4.5
Solar and photovoltaic	46.8	248	189	9.7
Wind	34.7	121	287	7.2
Total alt. energies	240.6	752	320	49.9
Energy efficiency				
Agro-food	14.0	48	292	2.9
Buildings	15.5	96	161	3.2
Industry	135.5	278	487	28.2
Energy industry	33.8	56	603	7.0
Transport	17.7	48	369	3.7
Total energ. eff.	216.5	526	412	45.0
Electricity and heat	24.3	44	552	5.1
Grand total	481.4	1 322		100.0

Source: DG XVII contracts.

In the *solid fuels* sector, the programme is divided into two parts relating to the *liquefaction and gasification of solid fuels* and to the *utilization of solid fuels* (see Table 3).

The *hydrocarbon technology development programme* was launched in 1974 and the current phase is covered by a Council Regulation in force from January 1986 to the end of 1989.

From the beginning of the programme to the end of 1987, 516 projects had been selected for financial support totalling ECU 426 million.

Half of these projects, 258, had been completed; 39% were in progress. The remaining 11% represented technical or financial failures.

Table 3

Distribution of support in the solid fuel sector

Subprogramme	Amount allocated (MECU)	Number of projects	Average amount per project (MECU)	% of total
Liquefaction and gasification				
Gasification	116.5	21	5.5	45.6
Underground gasification	21.9	2	11.0	8.6
Liquefaction	37.5	6	6.0	14.7
Total L & G	175.9	29	6.1	68.9
Utilization				
Fluidized bed combustion (FBC)	27.6	15	1.8	10.8
Pressurized FBC	13.2	4	3.3	5.2
Coal-water mixtures	18.8	13	1.4	7.4
Combustion of pulverized coal	6.3	9	0.7	2.5
Waste, environment	8.8	7	1.3	3.4
Miscellaneous	4.8	7	0.7	1.9
Total utilization	79.5	55	1.4	31.1
Grand total	255.4	84	4.2	100.0

A — Evaluation of the energy demonstration programme

The energy demonstration programme was initiated in 1978 and the current phase is governed by a Council Regulation[1] which has applied since January 1986 and will expire at the end of 1989. As the programme is nearing its end, the Commission has had it evaluated by independent consultants.

Their detailed reports are set out in two separate documents,[2] one concerning general aspects, energy efficiency, renewable energy sources, electricity and heat, the other on coal and other solid fuels.

1 Council Regulation (EEC) No 3640/85 of 20 December 1985.
2 Evaluation of the energy demonstration programme:
(i) 'Energy efficiency and renewable energies projects', November 1988, Mr Caprioglio and March Consulting Group;
(ii) 'Solid fuels', November 1988, Mr Thurlow and Mr Kallebach.

The reports come to the conclusion that the programmes have stimulated the development of innovative technologies, some of which have had a considerable impact, thereby contributing to the diversification and security of the Community's energy supplies and strengthening the Community's industrial base in the areas concerned.

Both reports are emphatic that further action is needed. Continued and indeed accelerated technological progress is essential if the Community's energy policy objectives for 1995 are to be attained. The energy scene in the years ahead and the degree of security of supply enjoyed by the Community will depend heavily on the improvements made in energy technology.

However, the reports also indicate that changes are needed to bolster the programmes and to take account of a new, wider-ranging set of Community policy objectives. Besides their established role in Community energy strategy, the programmes should contribute towards strengthening trade and industry in the Community in the framework of the internal market. At the same time they should help consolidate economic and social cohesion within the Community and make a major contribution to protecting and cleaning up the environment.

Nevertheless the reports are not without criticisms of the existing programmes. For example, the consultants feel that the energy demonstration programme should be given an added dimension by substantially stepping up the consolidation activities. More should be done to disseminate and promote successful demonstration projects throughout the Community and to circulate the results more widely in order to boost the impact and cost-effectiveness of the Community programme.

In particular, the consultants recommend placing greater emphasis on dissemination projects aimed either at spreading successful technologies throughout the regions of the Community or at assessing variants of the same technology. Joint ventures between firms from different Member States should be encouraged. There should be more projects involving small firms which have so often proved fertile ground for innovation. The consultants also suggest that the Commission could target projects on demonstrating the benefits of specific technological responses to particularly pressing problems, such as the environment, or on supporting projects best carried out as joint ventures between several European firms.

(i) In their sector-by-sector analysis, the experts start by stressing the need for a full range of measures on energy saving, covering information, financial support and rules and regulations, all with a view to improving energy management and protecting the environment.

(ii) Next, the experts emphasize the need to analyse the situation in each Member State with regard to legislation on buildings and energy efficiency, the thorny problems of energy labelling and energy audits, the establishment of channels of information and the replication of successful projects.

(iii) On industry, the experts appreciate the vast range of activities undertaken, particularly on the harnessing of residual heat. However, they note that more needs to be done on electricity consumption (5% of the projects). They also say that the procedure for pinpointing gaps in the market and potential new applications could be improved.

(iv) Turning to transport, action is needed on new, more efficient materials and on revamping existing transport facilities (e.g. by means of better traffic management). The introduction of enhanced information systems will be a key factor in this process.

(v) Next the evaluation mentions several times that projects concerning solar energy, wind power, geothermal energy, low-power hydroelectric schemes, biomass and waste have been particularly hard hit by the fall in energy prices, which has considerably weakened the prospects of these technologies making inroads into the market.

(vi) Consequently, further support should be given to the development of these energy sources, particularly for projects to evolve more competitive technologies. Secondly, greater attention should be paid to proven technologies which still need demonstrating in other regions of the Community to show that they are viable in different geographical conditions. Last but not least, particular care must be taken to circulate the results of the projects so as to keep potential regional or local project sponsors fully informed.

(vii) The section of the evaluation on electricity and heat states that there is a continuing need to demonstrate innovative technologies in this sector. More efficient management of electricity distribution grids offers considerable energy-saving potential at comparatively low cost.

(viii) Improvements in the performance of existing district heating networks also hold out promise, but seasonal heat storage systems have run into commercial viability problems.

(ix) On solid fuels, the evaluation emphasizes the urgent need to start or step up demonstrations of combined cycle electricity generating plant.

(x) Next the evaluation emphasizes that the Community programme on coal gasification and liquefaction has prepared the ground for technologies which could be used in the future, even if they are not economically feasible at the moment.

Nevertheless, certain applications, such as the use of producer gas in industry, may still find a market.

(xi) Finally, on coal combustion and related activities, the experts suggest that the work on fluidized bed technology should be stepped up.

It should focus on the environmental protection aspects, i.e. on reducing the quantities of pollutants produced and on waste-disposal and pollution control technologies.

On the other hand, the evaluation was critical about the application of coal-water mixtures technologies, an avenue which the experts felt should be abandoned.

B — Evaluation of the oil and gas technology support scheme

A firm of independent consultants, Smith Rea Energy Associates Limited (SREA), has evaluated the Community programme of support for technological development in the oil and gas sector.

With the assistance of a nine-man team of European experts in each of the fields covered by the programme, SREA assessed the results of the 516 individual projects supported.

The three principal conclusions to emerge from SREA's comprehensive appraisal are that the Community programme has:

(i) contributed to the Community's security of supply;

(ii) significantly speeded up the pace of technical advance;

(iii) fostered a Community identity in the oil and gas prospecting and production industry.

Consequently, SREA strongly recommends that the scheme should continue.

Examples of the major technical achievements which have contributed directly or indirectly to the Community's security of supply include:

(i) the Transmed pipeline transporting 12 billion cubic metres of Algerian gas to Italy 150 km across the Mediterranean every year at water depths of 600 metres;

(ii) the Single well oil production system (Swops) to exploit a marginal field in the North Sea;

(iii) horizontal drilling to double oil production in the Rospo Mare field off the Italian coast;

(iv) enhanced oil recovery by means of gas injection to treble output from the Ponte Dirillo field in southern Italy.

Other projects which have had a major impact on technological progress include:

(i) widely used seismic prospecting methods;

(ii) a world-first welded toroid design for submersibles, combining a structure lighter and cheaper than cast steel with considerable oxygen storage capacity;

(iii) a wireline system for servicing subsea wells, which has been successfully used in the Argyll field in the UK sector of the North Sea;

(iv) advanced hydrogen life support systems enabling divers to work at 520 metres below sea level, giving European industry a lead in deep-sea diving;

(v) development and successful testing of deep-sea pipeline repair systems;

(vi) development of an oil/gas separation system to provide better environmental protection;

(vii) reliable methods of monitoring the dynamic behaviour of offshore platforms with a view to increasing safety;

(viii) successful testing of the world's biggest pile-driving hammer;

(ix) application of the first mechanical pile/platform structure connection system in the Ravenspur field.

In several cases the support has been repaid since the technology is now on the market. This obligation to repay any support granted to techniques, processes or products which prove a commercial success is a safeguard to maintain fair competition. Following industrial application of the successful technologies some 25% of the total amount of support granted has been repaid.

One of SREA's main findings was that service companies have been the most successful contractors and design companies the least successful. Projects aiming at producing a manufactured product have had a high success rate, particularly where the potential end-users, the oil companies, participated.

The programme has acted as a catalyst for significant technological developments and a pooling of efforts by the industry throughout the Community. In recent years small firms have become more heavily involved, while oil companies' involvement has been declining. More and more projects are entailing cooperation between firms in different Member States in line with the new guidelines set out in the 1985 Regulation.

Despite a number of setbacks, the European industry has steadily expanded and strengthened its technological base in the course of the programme. By contrast, its main competitor, the USA's oil-related industry, has gone into decline, dramatically scaling down its research and development activity.

SREA recommends that the programme should continue for three reasons:

1. The Community will still have to safeguard its security of oil and gas supplies into the next century, regardless of any short-term fluctuation in prices. Oil and gas will continue to be the dominant energy sources in the Community and in the rest of the world for a long while to come.

2. Today the Community has a unique opportunity to occupy a leading position in the world's oil-related industry, which is bound to boost the Community's foreign trade.

3. Finally, the programme will help to build a sound industrial base for the oil-related sector in preparation for completion of the internal energy market in 1992.

European technologies for energy management

Thermie programme

The drive towards completion of the Community internal market is now irreversible. It will mean a stronger European Community, both internally and in its relations with the outside world. Secure and economic energy supplies are an essential foundation for this new Europe. Energy security policy is therefore a key flanking policy for the internal market. It is the Commission's role to provide the framework for ensuring secure and reasonably priced energy supplies. New energy technologies will make a critical contribution to that aim.

The Community's present energy demonstration and hydrocarbon technology programmes expire at the end of this year. It is essential that development of new energy technology continues at Community level, not simply by extending the current programmes, however successful they have been, but by initiating a new energy technology programme, geared to the wider needs of our Community in the 1990s.

A new programme for the promotion of energy technologies is necessary to enhance security of supply and to improve cooperation between industries at Community level to strengthen the Community's technological and industrial base. Such a programme also has a key role to play in meeting the environment challenge. The new technology initiative will also aid economic and social cohesion within the Community by transferring technology to the disadvantaged regions.

The Thermie programme will provide support for both innovation and for the dissemination of effective technologies in the energy field. It will cover energy efficiency, renewable energy sources, clean use of coal and oil and gas exploration and development. The emphasis will be placed on dissemination, both by encouraging investments in successfully demonstrated technologies in other regions of the Community and by publicizing the results of successful projects.

This article presents the arguments in favour of a new Community initiative in the field of energy technologies and describes the main features of such a programme. It is based on a recent Communication from the Commission to the Council (COM[89] 121 final of 22.3.1989).

The new economic and industrial context provided for Europe by the internal market objective will require a strong energy base. The Community's energy situation still suffers from insecurity, regional disparities and unresolved environmental concerns. The key to these problems is to develop and exploit new energy technologies.

The regulations[1] governing the Community's energy demonstration and hydrocarbon technology programmes expire at the end of 1989. The Commission has reviewed the future of these programmes in the light of the new economic prospects created by the unification of the internal market, and the need for effective flanking policies. The programmes have also been assessed by independent experts,[2] whose conclusions reinforce the Commission's view that a new initiative should be taken in this field. The Community should now build on the success of its energy research and demonstration programmes by putting the new technologies to work in a Community energy technology programme.

The following section outlines the case for a new Community energy technology initiative. This is followed by a description of the main features of such a programme.

The case for a new initiative

Internal market and energy security

The movement towards completing the internal market has become irreversible. For Community industry to take full advantage of the internal market, it must have access to secure

1 Regulations (EEC) Nos 3639/3640/85 of the Council, 20.12.1985.
2 Evaluation of energy demonstration programme:
(i) 'Energy efficiency and renewable energies projects' November 1988; Mr Caprioglio and the March Consulting Group;
(ii) 'Solid fuels', November 1988; Mr Thurlow and Mr Kallebach;
(iii) Evaluation of the European Community's programme of support on technological development in the hydrocarbons sector, August 1988, Smith REA Energy Associates Ltd.

and competitive supplies of energy. European industry would otherwise be seriously weakened in relation to its competitors overseas.

The present relaxed state of world energy markets should not be a reason for complacency. The Community's energy situation remains vulnerable. Nearly half of our energy requirements are at present imported. In the case of oil, the Community is dependent on other countries for over 70% of its needs.

Uncertainties still cloud the energy horizon. The future course of oil markets will continue to inject insecurity into the energy equation as long as so much of the world's supplies come from a region where political tension remains endemic. Nuclear power faces public opposition in many Member States and coal, one of the other major alternatives to oil, will encounter growing environmental constraints unless existing technologies can be improved.

In the past, technology has played a major role in improving the energy situation, in strengthening security of supply and reducing energy costs. To insure against the uncertainty of the future, and to underpin the achievements of the internal market, it is vital that energy technologies continue to play a central role.

The new technologies will help us to develop our indigenous energy resources, extend their lifetime and ensure they are produced economically. Their exploitation will enhance security of supply, lower energy costs and help the Community's balance of payments.

Technology is also the key to improving energy efficiency. As well as bringing economic benefits, this is essential for the environment and will also enhance security of supply by reducing the amount of energy we need. It is particularly important at the present time when energy prices are low to step up efforts in this direction, to compensate for the weaker signals coming from the market.

Technology can contribute significantly to diversifying energy supplies by facilitating the development and use of alternatives to oil, the exploitation of indigenous resources, including renewable sources, the clean use of coal and the production of energy from waste materials or waste heat. And in the oil sector itself, improved technologies can widen the range of supply sources.

Internal market and Community industry

The Single European Act explicitly states the need to strengthen the technological basis of European industry. In Article 130 it emphasizes the Community's role in encouraging undertakings to cooperate with one another and enabling them to exploit the internal market to the full. These requirements are as essential in the energy technology field as in other technology areas.

As the global market becomes increasingly accessible, and industry becomes more and more international in outlook and organization, it is appropriate that energy technology takes on an increasingly international aspect. This is especially so in the context of a single, integrated Community market. Cooperation at a European level can help to allocate available funds more efficiently, avoid undesirable duplication and support access to new technologies by lower income countries. The development of new technologies, together with effective diffusion of knowledge and experience, can promote the transfer of technology within the Community, facilitate industrial integration and create a sense of Community identity in the sectors concerned.

New technology will also contribute to the establishment of consistent norms and standards of performance and quality, thereby helping to remove trade barriers and to facilitate European integration.

The new Community energy technology initiative will specifically encourage joint ventures between undertakings from more than one Member State. Particular emphasis will also be given to support for small and medium-sized undertakings as well as to ways and means of strengthening dissemination of technology information throughout the Community.

The new initiative will take into account energy technology schemes at national and regional levels, as well as other Community programmes, to ensure effective coordination.

Technology transfer

Turning to the developing countries, the challenge will be to not only bring benefits to the Community, but also to transfer technology to our Third World trading partners. New energy technologies developed in the Community will have an important role to play in helping to solve the massive energy and environmental problems in the Third World. Greater participation by Community industry will also increase interdependence between Europe and the developing nations, bringing economic benefits to all concerned and enhancing the Community's security of energy supply.

Research and technology

As shown by the first report on the state of science and technology in Europe, adopted by the Commission on 15

November 1988 (COM[88] 647 final), a considerable effort has been made to improve the situation in Europe. This lies just behind the main competing blocks of the United States of America and Japan, but is also threatened by the initiatives of the new scientific and technological powers represented by the newly industrialized countries. This effort must therefore be reinforced. It is in this context that the new Community initiative is situated, which, leading on from the technology R&D Community framework programme, will allow the Community a greater ability, with the necessary continuity, to follow its technological choices.

Environment

There is increasing and world-wide concern about damage to the environment. Environmental issues such as acid rain, the ozone layer, the dumping of toxic waste and the warming of the world's climate (the 'greenhouse effect') are high on the political agenda. The Single Act recognizes the importance of environmental issues and states that environmental protection requirements must be a component of the Community's other policies.

The production, transportation and use of energy make significant demands upon the environment. There is growing recognition that constraints are necessary, and regulations have been introduced at national and Community levels, for example on emission levels and the sulphur and lead content of particular oil products. It is clear, however, that much more needs to be done to ensure that energy production and use is compatible with rising environmental standards.

Energy technology has a key role to play in meeting the environment challenge by making it possible to reduce energy consumption, by developing new and renewable sources and by ensuring the clean use of coal. Major efforts in all these areas will be needed to face up to the threat of climatic change. In addition, improvements to health and safety standards, for example in the field of hydrocarbon production, should also feature in an energy technology programme.

The Community's energy objectives for 1995[3] call for balanced solutions as regards energy and the environment, by making use of the best available and economically justified technologies and by improving energy efficiency. The new energy technology initiative will be central to achieving this objective.

Economic and social cohesion

The Single Act requires the need for economic and social cohesion to be taken into account when defining common policies. The new Community initiative in technology will bring important benefits to the least-favoured regions of the Community.

As a general rule, the less prosperous regions of the Community tend also to be the least-favoured from an energy point of view. The large, economically-recoverable reserves of coal, oil and gas are generally to be found in the more prosperous northern Member States. The least well-endowed regions in the south and on the periphery of the Community also tend to have less well-developed energy infrastructure connections to the rest of the Community or to outside energy suppliers. In consequence such disadvantaged regions generally exhibit a high dependence on imported oil and high energy costs.

The new technology initiative will help to reduce this energy imbalance within the Community by transferring technology to the disadvantaged regions. The poorer regions will benefit directly from Community support and from sharing the technological knowledge and experience developed elsewhere in the Community. Energy technology projects in these regions will, moreover, act as a catalyst for growth in the local economy, bringing also a climate of increased confidence to the areas concerned.

The application of these technologies will improve the energy situation in the less developed regions, increasing the efficiency of energy use and making it feasible to exploit local fossil and renewable energies. Such sources as wind and solar energies or small hydro very often offer considerable potential at a regional or local level, in addition to improving the local environment.

The social benefits to be derived from the use of new energy technologies should also be substantial. Employment opportunities will be created as the sectors concerned expand. It has been estimated by an independent institute that increased efforts to save energy and use waste heat or renewable energy sources could lead to the creation of as many as 530 000 jobs by the year 2000.[4] Energy conservation also provides social benefits in terms of reduced fuel bills for those most in need — lower income groups, the unemployed, pensioners etc.

It should also be kept in mind that there are still isolated localities in the Community, not connected to electricity

3 Council Resolution, 16.9.1986, OJ C 241 p. 1.

4 'Employment aspects of energy conservation investments in EC countries', Fraunhofer Institute (ISI), November 1984.

or gas networks, where the population lacks the normal access to energy supplies. Innovative technologies, particularly in the field of renewable energies, can make a significant contribution in alleviating this type of problem.

A new programme for the promotion of energy technologies

The needs identified in the first part of this paper can only be met by promoting the widespread use of new technologies to improve both energy supply and energy use in the Community.

The latest independent evaluations confirm that the Community's existing demonstration and hydrocarbon technology programmes have been successful in bringing a range of new energy technologies to the stage of commercial viability. They have provided a vital link in the technology chain, building on the Community's non-nuclear energy research and development programme by demonstrating the use of the new technologies on a commercial scale. The evaluations identify a continued need for this support for innovation.

A new initiative is necessary, however, to go beyond demonstration and ensure a substantial impact on the Community's energy situation. The experience gained in the existing programmes, reinforced by the conclusions of the independent evaluation reports, indicates that this can only be achieved if new initiatives are taken to bridge the present 'inertia gap' that exists between successful demonstration and the use of new technologies in the marketplace. This aim must be the basis of *the new programme for the promotion of Community energy technologies*.

The Commission agrees therefore with the views expressed in the independent evaluation report on the demonstration programme:

'Hardware demonstration on its own ... is therefore unlikely to be sufficient to ensure a suitable and effective link with the marketplace.'

and

'the characteristics of the energy market are such that a very deliberate emphasis needs to be focused on consolidation and promotional activities, if the vast body of knowledge stemming from current R&D and demonstration efforts is to make the required impact.'

The new Community initiative must therefore provide support both for innovation and for the dissemination of effective technologies. It will thus give added substance to the 1995 energy objective which requires continuous and diversified promotion of energy related technological innovations through R,D&D and rapid dissemination of the results throughout the Community. This new initiative will also complete and reinforce the activities undertaken in the Strategic programme for innovation and technology transfer (Sprint).

In the new programme, therefore, more emphasis should be placed on dissemination, both by encouraging investments in successfully demonstrated technologies in other regions of the Community and by publicizing the results of successful projects. By this means, major benefits will accrue from the Community dimension, ensuring that maximum added value is derived from Community funding. This will be of particular help to innovative small and medium-sized enterprises which will often, without Community assistance, financial or otherwise, encounter difficulties in promoting successful new technologies beyond national boundaries. On the other hand, this initiative will also put to use the results of national and Community R&D programmes and will reinforce the activities undertaken by the valorization and utilization for Europe programme (Value).

The new programme would cover the following areas:

(i) energy efficiency;

(ii) renewable energy sources;

(iii) clean use of coal;

(iv) oil and gas exploration and development.

The efficient use of energy must clearly be given high priority to eliminate unnecessary consumption and reduce environmental pollution. This section of the programme will cover:

(i) Buildings: technologies for retrofitting, new processes or products for construction, heating systems;

(ii) Industry: improvement of existing or development of new production processes, recycling of waste heat, computerized energy management systems etc;

(iii) Transport and urban infrastructure: vehicles and transport systems, with particular emphasis on urban traffic and alternative fuels;

(iv) Electricity and heat: for instance electricity use, production, storage, use of residual heat from power plants for district heating networks etc.

The *renewable energies* field covers projects for the exploitation of non-exhaustible energies, notably in the following sectors:

(i) *solar energy*, with the conversion of this source to thermal energy by active or passive methods, or by conversion to electrical energy by photovoltaic processes;

(ii) energy from *biomass*, agricultural products and waste matter, as well as plants cultivated for energy production;

(iii) *geothermal energy* for heating, use of heat in industrial or agricultural processes and for electricity generation;

(iv) *hydroelectric energy* for the production of electricity by low power hydroelectric plant;

(v) *wind energy* for electricity generation.

In the case of *coal and other solid fuels* it will be essential to promote the development and use of clean combustion technologies capable of meeting future environmental needs. The problem of effluents will also need to be addressed. Particular emphasis should certainly be placed on the production of electricity by means of coal gasification using the so-called IGCC (Integrated gasification combined cycle) technology, which shows considerable promise in both cost and environmental terms.

The *oil and gas* section of the programme will cover exploration, production, storage and transportation activities in the hydrocarbons sector. More efficient and innovative techniques will make it easier to explore for and produce new reserves, both onshore and offshore, thus improving supply security in the Community. Safety will be another area for technology improvements. In this section also, preference will be given to cooperative projects and projects involving small and medium-sized enterprises.

The new programme will have two major axes: The first is the promotion of three types of projects (innovation, dissemination and targeted) by way of financial support towards their realization. The second is a set of consolidation activities for the diffusion of results and to facilitate the repetition of successful projects. These activities will be undertaken in collaboration with other Community programmes aimed in particular at R&D (Joule), innovation and technology transfer (Sprint) and the dissemination and utilization of the results of scientific and technical research (Value).

Innovation projects will show for the first time that new technologies can be exploited successfully on a commercial scale. Dissemination projects on the other hand will encourage the wider use of a new technology after the first successful project. In addition, a central role will need to be assigned to targeted projects. These projects will be carried out at the Commission's own initiative, after appropriate inter-service consultation, to prove the advantages of specific favourable technologies. They will include, for example, pilot projects designed to promote the further use of technologies already proven at the R&D stage. These will for instance be used to provide answers on matters of special concern such as the environment, as well as to support projects better undertaken on a cooperative basis by a number of EC firms. The Consultative Committee set up under the new programme will need to consider what proportion of the total budget should be assigned to such projects, and whether they should receive a higher rate of support.

Consolidation activities will be strengthened. These include effective auditing and monitoring of projects, technology and market assessments, diffusion of results and promotional efforts, and cooperation seminars or fora to bring EC companies together. In addition to improving the commercial success rate of the projects selected, these activities will also provide an essential feedback from the marketplace into a strategic approach for the new programme as a whole. Thus they will contribute to the identification of future innovation priorities and to decisions about their funding. These activities will be undertaken after consultation and in collaboration with the appropriate services of the Commission.

Preference should clearly be given to joint venture projects involving at least two independent undertakings from different Member States. This will strengthen the Community dimension in the sectors concerned and aid the transfer of technology across national boundaries.

Preference should also be given to small and medium-sized enterprises (SMEs), which are a frequent source of innovative thinking. This category of enterprise often lacks the necessary funding to develop new technologies and bring them to the marketplace. Nor will SMEs generally have sufficient resources to disseminate new technology or diffuse information to other Community regions. The Community therefore has a special role to play in providing assistance to SMEs in the energy technology field.

As far as dissemination projects are concerned, preference should clearly be given to those located in the less prosperous regions of the Community. In this way the new programme would provide an essential complement to Valoren which is being used, within the ERDF, to finance investments beyond the innovation stage in fields such as energy efficiency and renewable energies. The combined effect of these two programmes would help to overcome the present weaknesses in the energy situations of these regions.

To fulfil its objective of accelerating the use of the new energy technologies in the energy market, the new programme will need to introduce decision procedures which are faster, more flexible and more efficient. Under the present programmes it is only possible to take one set of decisions each year. The Commission and the Consultative Committee established under the new programme should agree on procedures which can reduce this delay to a level more acceptable to industry.

There is also a need to re-examine management procedures for technology projects. The Commission's views is that there is scope for improving management efficiency by making more use of resources in Member States, both within and outside governments. This need for greater subsidiarity in programme management is now being actively studied in a wider sense by the Commission's services. Specific proposals on how to achieve a greater national participation in the technical, contractual and financial management of energy technology projects will be made before the end of this year in the light of those studies.

In the light of the experience and results of the existing demonstration and hydrocarbon technology programmes, it has been suggested that the new programme, taking the four main technology sectors together, will require a significantly higher level of funding than the ECU 125 million a year allocated to the current programmes in the period 1986-89. A reasonable duration for the new programme is also essential for industrial confidence and to allow its objectives to be pursued consistently. It has therefore been proposed that the new programme should be authorized for a period of five years with an estimated total funding over that period of the order of ECU 700 to 750 million. However, the Commission has not yet deliberated on the budgetary envelopes which it will propose to be allocated for the Thermie programme. For this reason these amounts are purely indicative and should not be taken to prejudge the conclusions of the Commission.

The Community coal economy and its prospects

The Community coal economy has changed since 1973 with respect to demand and supply patterns and is likely to change in the years to come. Although overall demand virtually remained stable, steam coal demand for power generation increased considerably. On the supply side, Community production decreased, and in part has been replaced by imports. The present article deals with a detailed analysis of these developments and their underlying factors and gives a tentative outlook for 1995. Although the relative importance of lignite has increased since 1973, this paper focuses on hard coal, since lignite is hardly traded internationally. According to the two main purposes of present coal use — steam raising and coke making — this paper deals with both utilization sectors and the corresponding kinds of coal separately.

Coal demand

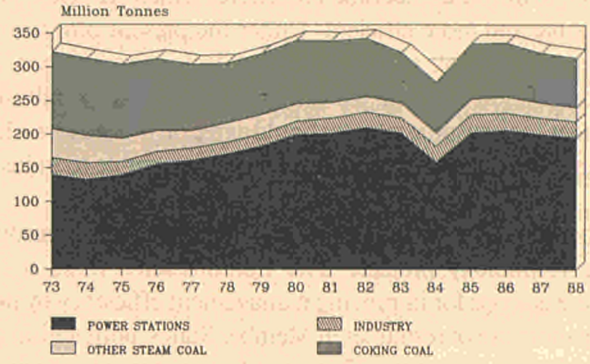
Total hard coal demand in the EC at present amounts to some 315 Mt. This is about the same value it had attained before the first oil price crisis in 1973. As can be seen from the following graph, coal demand as a whole virtually remained stable throughout the last 15 years. Within this narrow range coal deliveries were at their maximum in 1982 (342 Mt) and fell to a minimum value in 1984, when British miners decided on a year-long strike. However, the slump of oil prices in 1986 was followed by a slight downward movement of total demand.

While overall coal demand did not change much, there have been important structural shifts. Coking coal deliveries dropped by 36% between 1973 and 1988, whereas steam coal demand grew by 16%, increasing its market share from 65% to 77%. The expression coking coal is applied here for coals being processed in coking plants or used to replace coke in blast furnaces, while steam coal or thermal coal comprises all other coals. Thus, coals even having good coking properties are also included in the category steam coal, if they are actually burnt for thermal purposes.

Steam coal

Steam coal at present is burnt predominantly in power stations, but substantial amounts of steam coal are used in industry. In addition, various other smaller consumption sectors, like households, public buildings, district heating plants etc. also burn thermal coal. However, future prospects for steam coal sales depend mostly on the development in power stations and general industry, which will be analysed in greater detail.

GRAPH 1
STEAM COAL AND COKING COAL DELIVERIES

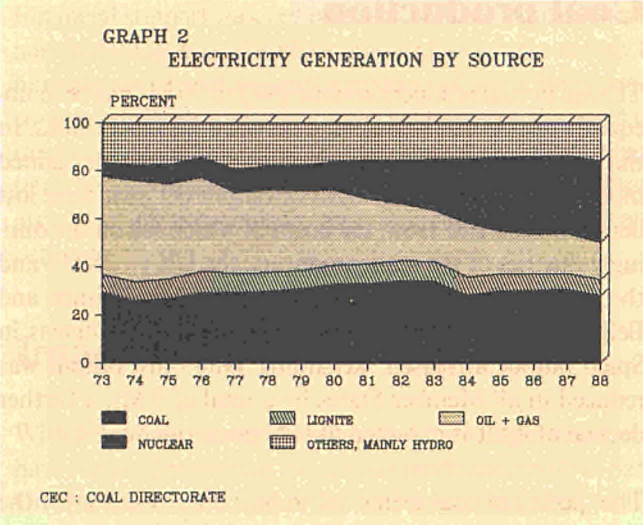


CEC : COAL DIRECTORATE

Total deliveries to power stations which had soared by 70 Mt or 50% between 1973 and 1982, showed no further growth thereafter, but decreased slightly to 196 Mt in 1988.

Whereas growing coal use in power stations in the 1970s up to the beginning of the 1980s clearly was a response to the dramatic oil price increase and the following national and Community measures to reduce oil consumption, the price incentive lost much of its vigour since the recent fall in oil prices. In the past the response to growing electricity demand and the need to reduce oil and gas consumption in power stations has been different between Member States partly according to their resource situation (reserves of coal/lignite, natural gas and hydro). Within the coal producing Member States the range stretches from a group including France and Belgium who now heavily rely on nuclear power to the group of the main coal producers (UK and the Federal Republic of Germany) who generate electricity mainly from coal. Spain lies half way between. Member States without significant coal production reacted in different ways. Most of them renounced nuclear power, except for the Netherlands, where some nuclear energy is employed. Instead of this they have increasingly used solid fuels in power stations, especially in Denmark and Greece, where 95% and 80% respectively of electricity is generated from solid fuels (in Greece almost exclusively indigenous lignite). In recent years also Ireland, the Netherlands and Portugal have considerably increased the share of solid fuels in electricity production.

Altogether the Community has based its electricity generation mainly on solid fuels and nuclear energy, the contributions of which amount to 35% and 34% respectively. The share of oil and gas which was as high as 42% in 1973 underwent an impressive reduction to 16% and the Community



objective for 1995 (share less than 15%) was nearly achieved already by 1988.

A recent study of Unipede (electricity producers and distributors) on the Community electricity sector forecasts a share of 12% for hydrocarbons by 1995 compared with shares of 34% for nuclear and 37% for solid fuels. The contribution of coal — according to that projection — will be 32%. This means a coal consumption for electricity generation of 201 Mtce in 1995 which is about 240 Mt.

Thermal coal deliveries to industry (without industrial power plants) which were on a continuous downward trend until 1978, recovered with the rise in oil prices in 1979/80 and reached 26 Mt in 1985. With the recent slump of oil prices industrial coal demand declined to 24 Mt in 1986. In 1987 and 1988 it stabilized at that level, partly on account of increasing industrial production.

Coal use in industry is highly concentrated on the coal producing countries. The UK, France, Germany and Spain account for three quarters of thermal coal consumption in industry. In countries without own coal basis, coal application in industry is rather limited, in contrast to the power station sector in those countries which import considerable amounts of coal. There is a variety of reasons for the low penetration of coal in industry, even in those periods when all kinds of coal had a clear price advantage; these reasons might be summarized as follows:

(i) higher investment costs of coal plants with pay back times perceived by industrialists as being too long, especially when utilization of existing oil/gas boilers could be continued;

(ii) operating costs being some 30 USD/tce higher for small coal-fired boilers;

(iii) lack of proven clean coal burning facilities for small consumers;

(iv) uncertainties surrounding future regulations limiting emissions from small and medium-sized boilers;

(v) a generally negative image of coal.

With present prevailing price relations to oil and gas the price difference even of imported coal is not sufficient to overcome the abovementioned obstacles. On the other hand, the potential for an enlarged use of coal in industry is high. With considerably increased efforts in the field of R,D&D in clean coal technology and/or new systems for selling heat instead of coal (for example by third party financing) as well as an appropriate price climate, some more coal might be burnt in industry — but the crucial factor still is the oil price development.

Other steam coal consumption, mainly for domestic purposes, is continuing on its downward trend and should decline further in the years to come. Exceptions to this could be public buildings and district heating systems, if an adequate price difference of coal with respect to natural gas and oil can be restored.

Coking coal

Whereas steam coal demand on the whole remained nearly stable between 1980 and 1988, demand from coking plants decreased markedly by 25 Mt to 69 Mt. Compared with 1973 the decline even amounts to 45 Mt.

As coking coal demand directly depends on coke production the structure of the coke market is worth analysing. Coke is used in industry, particularly steel industry and households. As the following comparison shows, coke demand has become increasingly dependent on the performance of the steel industry. Whereas in 1970 not even three quarters of coke were consumed in steel industry, this share — in a declining coke market — rose significantly to about 90% in 1988 and should continue to rise. Future coking coal demand therefore might be considered as a rather close function of the steel industry's requirements for blast furnaces and sinter plants. But there is no straightforward dependence of coking coal demand on steel output, given the great variety of existing steel-making technologies, notably those not using coke and the blast furnace.

Apart from the electric furnace which generally works on the basis of scrap, there are techniques for the direct reduction of iron ores. These iron-making processes, based on coal, completely eliminate the need for coke. Although the technology of direct reduction should become more relevant and the share of electric furnaces has been increasing throughout the last years and is expected to rise in the years to come, there is a widely held belief that the classical route of steel production via the blast furnace for the time being will remain predominant in the industrialized countries.

Within the Community the Commission foresees only a slight drop in the share of steel produced from pig iron by 1995. The combined effect of technology and a decreasing steel production as well as a considerable reduction in specific coke consumption per tonne of pig iron might result in a coking coal demand of steel industry by 1995 in the order of magnitude of 45 Mt. This is about 15 Mt below the requirements of the good steel year 1988.

Apart from the slightly increasing efficiency of blast furnaces, the reduction of specific coke consumption is mainly due to the ongoing substantial replacement of coke by pulverized coal injected in blast furnaces. Only some years ago the Community steel industry began using this technology on a rather large scale. Consumption of injection coal which was less than 1 Mt in 1985, grew to nearly 4 Mt in 1988. A further increase to about 6 Mt in 1990 is forecast by Cepceo, the Community coal producers' association. By then the Netherlands, Germany and the UK especially, having already today a comparably high penetration of injection coal, are likely to add another 2 Mt; but France and Belgium will also increase the use of injection coal in blast furnaces.

Among the various advantages of injecting coal into blast furnaces (greater choice in usable coal qualities, lower fuel costs, better performance of the blast furnace) the most important regarding future coking coal requirements is the fact that one tonne of injection coal replaces more than one tonne of coking coal. To the extent coal injection will make its way (about 100 kg/t of pig iron or even more are often stated as being perfectly feasible, compared with some 40 kg/t in the Community today) a marked decline in requirements for traditional coking coal has to be envisaged.

Coal supply

Whereas coal consumption today is of the order of magnitude of what it had been in 1973, the supply pattern has changed considerably. Production in 1973 stood at 283 Mt, from where it dropped to 213 Mt last year. Imports from third countries, on the other hand, tripled since 1973 to reach 98 Mt in 1988.

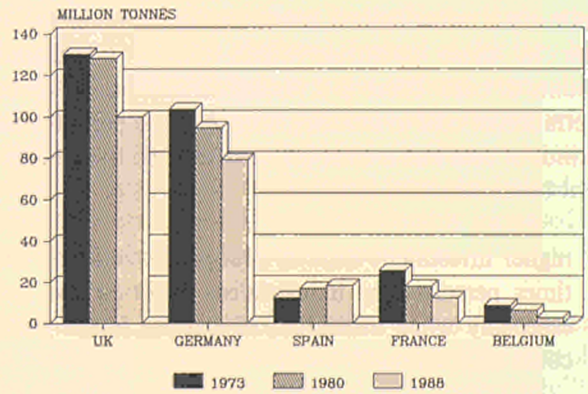
Coal production

The fall in coal production since 1973 of 70 Mt has been unequally distributed in time and between Member States. In the years after 1980 the downward movement gained momentum. More than 50 Mt of output per year were lost between 1980 and 1988, the brunt of which fell on the mining industries of the main producers: the UK (— 28 Mt) and the Federal Republic of Germany (— 15 Mt). France and Belgium considerably reduced production too, whereas in Spain output increased. Regarding 1988 only, output was reduced in all Member States by a total of 9 Mt, a further decline of 4 Mt is expected to take place this year.

The quality of coal seems not to be a crucial factor for the reduction of output, since all qualities are concerned. However, production costs and the political willingness of governments to subsidize their mining industries are decisive. With severe restrictions on budgets prevailing today many governments would like to have their financial engagement for coal mining reduced. Therefore plans exist to reduce output in some Member States in the years to come. Furthermore, State aids can only be granted, if they are considered by the Commission as being compatible with the proper functioning of the common market. The new Community rules for State aids to the coal industry (Decision No 2064/86/ECSC) require that State aids eligible for authorization shall help to achieve at least one of the following objectives:

(i) improved competitiveness of the coal industry, helping to ensure better security of supply;
(ii) creation of new capacities as long as they are economically viable;
(iii) solution of social and regional problems related to changes in the coal industry.

GRAPH 3 : HARD COAL PRODUCTION



CEC : COAL DIRECTORATE

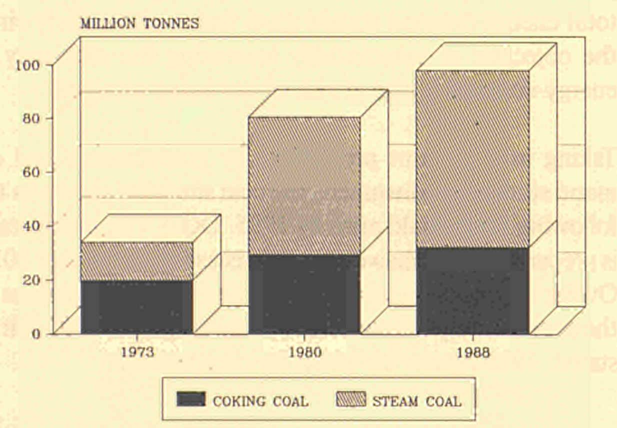
Financial support for coal production made available from national budgets is therefore intended to a large extent to mitigate social and regional problems of the mining areas concerned. With a view to the completion of the internal market, the Commission will apply rigorously in the energy field the rules of the Treaty regarding State aids, so as to avoid distortion of competition and to allow increased competitivity.

Imports

With low prices on world coal markets, soaring coal imports have replaced expensive indigenous production only in part. On the other hand, imported coal has contributed to the restructuring of the Community energy balance by replacing oil and gas in electricity generation.

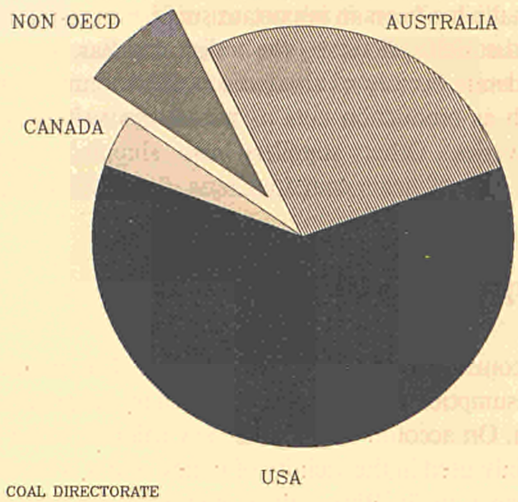
Imports nearly tripled since 1973, mostly on account of booming steam coal deliveries from third countries which in 1988 were more than four times as high as in 1973. Coking coal imports, on the other hand, showed a more moderate growth, of some 60%. The structure of Community coal imports has been reversed from a 60% share of coking coal in 1973 to only one third in 1988.

GRAPH 4 : EC COAL IMPORTS



CEC : COAL DIRECTORATE

GRAPH 5 : COKING COAL IMPORTS 1988

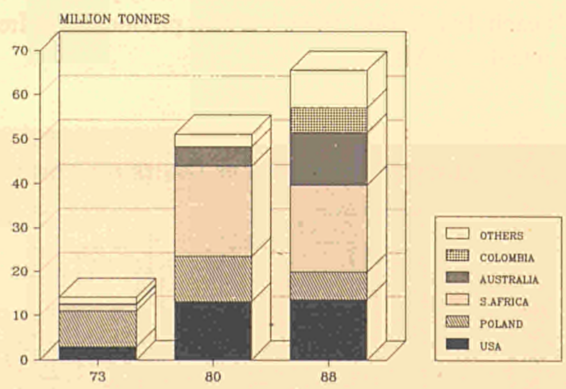


CEC : COAL DIRECTORATE

Community coking coal imports are traditionally based on supplies from the USA which account for some 60% of deliveries. Nearly 30% at present are supplied by Australia. Less than one tenth of coking coal imports is delivered by non-OECD sources, mainly Poland and the USSR.

Steam coal imports of all Member States show an upward trend since 1973, but there is no uniform development. Member States without their own coal base, especially Denmark, Italy and the Netherlands, accounted for most of the increase. But coal-producing Member States — like Belgium and Spain — have also increased their steam coal imports substantially. Ireland and Portugal started to expand their purchases from third countries only recently. French imports of steam coal were soaring until 1980 by 13 Mt, but with the massive connection to the grid of nuclear power plants they dropped again by almost the same amount.

GRAPH 6 : STEAM COAL IMPORTS



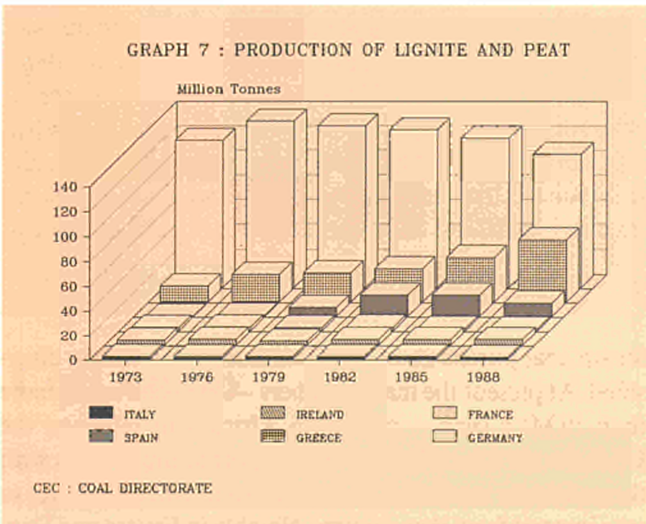
CEC : COAL DIRECTORATE

Steam coal purchases of the Community are widely diversified. At present the main suppliers — each delivering more than 10 Mt a year — are South Africa, Australia and the USA. South Africa lost much of its predominant role with the politically motivated decision of some Member States to stop imports from that country. Notably in France and Denmark these imports ceased or decreased sharply to the extent that old contracts are still carried out. One clear gainer by these measures has been Colombia. This newcomer has substantially increased deliveries of steam coal to the Community, especially to Denmark and France. Poland traditionally has been an important supplier of the Community. In the 1980s, however, the Polish role has become rather moderate by way of comparison due to internal problems such as production cuts or not always sufficient internal deliveries. Other suppliers also shipping considerable amounts of steam coal are China, the USSR and Canada.

Lignite and peat

In contrast to the hard coal situation, Community lignite consumption is almost entirely based on indigenous production. On account of its rather low calorific value lignite is mainly used in the vicinity of mines, and it is hardly traded internationally. Within the Community the only exception is the Federal Republic of Germany. Although being the major producer of lignite in the Community, Federal Germany imports some lignite from Czechoslovakia and a rather small quantity of lignite briquettes from the German Democratic Republic.

Community lignite production has risen considerably by 35 Mt over the last 15 years to reach 176 Mt in 1988. This increase was virtually due to Greece, where production soared to 50 Mt in 1988, rendering Greece the second producer after Germany. The German production, on the other hand, declined to somewhat above 100 Mt last year. In Spain 11 Mt were mined in 1988, while France and Italy produced about 2 Mt each. In addition, there is a peat production in Ireland of some 4 — 5 Mt.



Nearly 90% of lignite available in the Community is used for power generation. A quantity of slightly less than 10% is processed to briquettes or other forms of dried lignite. These products are utilized mainly in industry or for domestic purposes. Although no sensible growth of this domestic and industrial market is to be expected in the years to come, the consumption of lignite for power generation should continue to increase as it did over the last two decades. By 1995, Unipede foresees an increase in lignite consumption by utilities of 17.5% compared with 1987.

Community energy objectives and outlook for 1995

Increasing imports could more than outweigh the decline in production scheduled for the years to come and therefore an increase in consumption is perfectly possible. However, Community energy objectives, adopted in 1986, are rather ambitious in this respect. It has been decided that the share of solid fuels in total energy consumption should be increased. This should be done by pursuing the efforts to promote consumption of solid fuels and by improving the competitiveness of solid fuel production in the Community.

By now it is becoming more and more clear that the target of increasing the share of solid fuels in energy consumption might not be attained by 1995. With no major changes in present circumstances for coal (especially oil prices and prospects for nuclear energy) coal demand is expected to rise moderately at best, as indicated by present consumption projections, for example by electricity producers. In any case, total energy demand should grow faster, particularly since the objective of substantially increasing the efficiency of energy demand is also at risk of not being attained.

Taking into account projections by governments and demand studies by consumers, the coal situation shown in the following table could arise by 1995. DG XVII, incidentally is preparing an extensive energy forecast up to the year 2010. Owing to prevailing uncertainties and differing opinions of the economic agents concerned, only ranges for 1995 can be stated. 1988 figures are given for comparison.

	1995	1988
	Mt	
Production (incl. recoveries)	190-210	218
Imports	140-150	98
Resources	330-360	316
Power stations	235-250	196
Coke ovens	51-55	69
Steel industry	7-8	4
Other industries	21-28	24
Households, others	16-19	21
Deliveries	330-360	314

A considerable growth of coal consumption by 1995 will occur only if existing plans to boost coal use in power stations are carried out in time. On the other hand, it is almost certain that demand from coking plants will decrease, and consumption in households should continue its downward movement. Apart from the steel industry, where the use of injection coal is scheduled to increase in the next years, a sensible forecast of coal consumption for other industries is extremely difficult. As mentioned above, there are a lot of obstacles to coal use in industry nowadays. The Commission of the EC, in pursuing the objective of increasing the share of solid fuels in total energy consumption, will pay particular attention to the industrial sector without neglecting the promotion of clean coal use in other sectors.

Greece

Energy profile

Gross energy consumption in Greece today totals around 20 Mtoe, almost 13 Mtoe of it in the form of petroleum products; Greece depends on oil for 64% of its energy supplies.

Per capita energy consumption in Greece is 1.82 toe, still some 45% below the 1987 Community average of 3.28 toe.

Since 1973 energy consumption in Greece has been growing by an average of 3% a year. Over the next few years this is expected to speed up (averaging 4% a year between now and 1995).

For a series of structural, economic and technological reasons, Greece still lags behind the rest of the Community on energy efficiency, with an energy intensiveness of 0.58 toe per ECU 1 000 GDP, compared with an average of 0.42 for EUR 12 in 1987.

Table 1 compares the past figures and the latest forecasts for the chief energy indicators in Greece with the figures for EUR 12 as a whole.

Table 1

Energy consumption in Greece and in the Community (EUR 12)

	Greece			EUR 12		
	1973	1987	1995	1973	1987	1995
Gross energy consumption (Mtoe)	12.5	19.9	26.7	1 029	1 092	1 166
Inland energy consumption Per inhabitant (toe)[1]	1.31	1.82	2.47	3.20	3.28	3.50
Share of oil in gross energy consumption (%)	81	64	55	63	46	44
Share of hydrocarbons in electricity production (%)	51	21	16	42	16	16
Supply dependance on imported energy (%)	93	63	65	65	45	50

[1] Assuming same population in 1995 as in 1987.
Source: See Table 2.

Energy policy

A steady energy supply at reasonable cost is the Greek authorities' overriding concern in their efforts to create the right conditions for economic development in their country.

Greece's heavy dependence on imported energy supplies, particularly on oil which accounted for 93% of the country's total energy consumption in 1973 and still accounts for 63% today, gives an idea of Greece's vulnerability to events on the international energy scene, such as supply crises or sudden price increases.

Consequently, Greece's energy policy has put the emphasis on reducing dependence on oil imports and diversifying the sources of supply. In the first phase, priority was given to:

(i) prospecting for and harnessing the country's indigenous oil resources;

(ii) stepping up large-scale production of lignite as an alternative to oil for electricity generation.

During the second phase the next stages of the diversification strategy were planned and introduced, including:

(i) importation of natural gas from Algeria and the Soviet Union;

(ii) development of renewable energy sources most of which display great potential in Greece.

Energy situation and outlook

Results of the energy policy

This energy policy has already produced tangible results:

(i) Oil production is up to 1.35 Mt, enough to cover 10% of Greece's requirements.

(ii) Lignite production has more than tripled to nearly 6 Mtoe and, according to forecasts, could reach 9 Mtoe by 1995.

(iii) The proportion of electricity generated from oil has been cut back from 51% in 1973 to 21% in 1987, thanks to the rapid spread of lignite-fired power stations. At the moment lignite provides 76% of the fuel burnt for electricity generation in Greece.

(iv) Greece has signed import agreements with two natural gas suppliers: the first gas should start to arrive in the 1990s by pipeline from the Soviet Union and in liquefied form from Algeria. By 1995 these sources should provide an estimated 6% of Greece's energy supplies.

(v) Several renewable sources are in use already or soon will be. Greece has more solar heating installations than any other Member State. Wind farms for electricity generation purposes are soon to be installed on a number of islands in the Aegean Sea (Crete, Lesbos and Limnos). On other islands, electricity will be generated from geothermal resources.

The priorities for the next few years are:

(a) constant development of renewables, particularly harnessing of the potential for large and small hydroelectricity plants;

(b) energy-saving campaigns to boost energy efficiency and cut Greece's energy bill.

Table 2 sums up the energy balance in Greece in 1973 and 1987 and the forecasts for 1995.

Table 2

Summarized energy balance - Greece

Mtoe	1973 A	1987 A	1995 B
Gross energy consumption	12.51	19.93	26.7
— Bunkers	0.83	1.79	2.0
— Inland consumption	11.68	18.14	24.7
Inland energy consumption	11.68	18.14	24.7
— Solid fuels	2.19	6.80	10.0
— Oil	9.28	10.94	12.8
— Gas		0.11	1.5
— Primary electricity etc.	0.21	0.29	0.4
Indigenous production[1]	1.97	7.56	9.3
— Hard coal			
— Lignite & peat	1.77	5.97	8.9
— Oil		1.24	
— Natural gas		0.11	
— Nuclear energy			
— Hydro & geothermal[2]	0.19	0.24	0.4
— Others & renewables	0.01		
Net imports[3]	11.60	12.64	17.4
— Solid fuels	0.46	1.11	1.1
— Oil	11.13	11.48	14.8
— Natural gas			1.5
— Electricity[3]	0.01	0.05	
Stock changes[4]	1.07	0.27	
— Solid fuels	0.04	0.28	
— Oil	1.03	0.01	
— Gas			
Electr. generation input	3.41	7.43	10.1
— Solid fuels[5]	1.47	5.65	8.1
— Oil	1.74	1.53	1.1
— Natural gas		0.01	0.5
— Nuclear energy			
— Hydro & geothermal[2]	0.19	0.24	0.4
— Others & renewables	0.01		

Sources: A: Statistical Office of the European Communities;
B: Submissions from Member States and best estimates from external sources.

[1] Production of primary sources including recovered products.
[2] The conversion of electricity, including hydro and geothermal, is based on its actual energy content: 3 600 kJ/kWh or 860 kcal/kWh.
[3] The (-) sign means net exports.
[4] The (-) sign means a stock decrease.
[5] Including coke oven gas and blast furnace gas (derived from coal)
General note:
Figures submitted by Member States have been adapted where necessary to ensure consistency with SOEC statistical definitions or conversion factors.

Oil industry

All the oil produced in Greece comes from the Prinos offshore field, with a current output of 1.35 Mtoe. Prospecting onshore and along the Ionian coast has failed to strike any other significant fields. There could well be oil under the Aegean Sea but prospecting and production there have been halted by Turkey's claims to part of the continental shelf between the Greek Aegean islands and mainland Greece.

Assuming no other fields come on stream, oil production in Greece will decline until the Prinos field is dry, in 1995 according to the latest estimates.

Crude oil imports for the Greek market are generally based on intergovernmental contracts. This oil is imported by the Public Petroleum Corporation (DEP), a State-owned company operating two refineries, one in Athens, the other in Thessaloniki. These supply most of the oil consumed in Greece.

Two other privately owned refineries, near Athens and Corinth, also import oil. Most of their output is sold on the Greek bunker fuel market to supply shipping and international air services, while the rest is exported.

All in all, the 11.5 Mtoe of oil imported in 1987 came from a fairly wide range of sources, led by OPEC (Libya and Kuwait), followed by the Soviet Union.

Electricity

Greece has proven lignite reserves of an estimated 5 530 Mt, of which 60% is rated economically recoverable. With such enormous reserves, it should be possible to maintain lignite production, even at the higher levels planned.

Almost all the lignite produced, roughly 6 Mtoe in 1987, is earmarked for electricity generation. The State-owned Public Power Corporation (PPC) has built lignite-fired power stations on site at the lignite fields.

Lignite is by far the leading source of electricity in Greece (it generated 76% in 1987). It is expected to extend its lead and increase its share to 80% by 1995 when four new lignite-fired power stations will be generating.

The remaining 20% will be divided between oil, gas and renewable sources, with oil taking a 5% share on remote island grids and another 5% at power stations interconnected to the mainland grid, natural gas moving up to 5% after conversion of an oil-fired power station in Athens and renewables, especially hydroelectricity, sharing the remaining 5%.

The lack of any common frontier with the other Member States or of any direct link with their transmission grids poses serious problems for Greece's security and continuity of supply and for intra-Community transfers. There are plans for interconnection with the southern Italian grid, but funding remains a problem despite the undisputed advantages in terms of greater security of supply and more stable transfers.

Conclusions

Great progress has been made on energy in Greece since 1973. The programme to make greater use of Greece's indigenous energy resources (lignite, oil and renewables) must be kept up to reduce the country's dependence on oil imports further still. Particular attention will have to be paid to ways of saving energy and using it as efficiently as possible.

Refining industry: A two-speed Europe?

On close analysis, there is a marked split in the refining industry between the north and south of the Community. This article explores these differences. However, this by no means implies accepting the idea of a two-speed Europe; it simply acknowledges that the different conditions in the north and the south must be taken into account. With this in mind, the first stage in any analysis of this divide must be to examine the basic data for the economy in general and the oil industry in particular in each of the two regions.

Greece, Italy, Portugal and Spain are classified as the 'southern Member States' in this article. It would be logical to include Ireland too, despite its geographical location, since it faces much the same refining problems as the southern Member States. However, this article keeps to a strictly geographical division and classifies Ireland as one of the northern Member States.

Differences between north and south

Economic structures are the first difference between the two halves of the Community.

Table 1 shows that agriculture features far more prominently in the south, but that industry and the services sector are weaker there.

Table 1

EUR 12: GDP by sector in 1985

(% of GDP)

	EUR 12	North Europe	South Europe[1]
Agriculture, forestry, fisheries	4	3	6
Industry and construction	36	37	35
Services	55	56	50
Others[2]	5	4	9
GDP	100	100	100

[1] South Europe: Italy + Greece + Spain + Portugal.
[2] VAT and net import charges.

Source: SOEC - Cronos database (ICG).

A second difference from the north is that per capita GDP is below the Community average in every southern Member State. Finally, the GDP growth rate is below or only just up to the Community average in every southern Member State except Italy.

Together, these factors go part of the way to explaining the differences in the energy scene in the two halves of the Community. However, other factors also come into play.

For example, the northern Member States import 60% of all the oil which they consume, whereas their southern partners depend almost entirely on imports, which cover 97% of their consumption.

The situation is similar for natural gas, though in this case both halves are far less dependent on imports (31% in the north and 53% in the south).

Tables 2 and 3 vividly illustrate the marked differences in the pattern of oil consumption in the two regions, notably the very high share taken by fuel oil in the south.

Table 2

EUR 12: Oil indicators (1987)

		EUR 12	North Europe	South Europe[1]
Oil consumption	(Mt)	500	345	155
	(%)	100	69	31
Oil's share of total energy consumption	(%)	46	41	60
Dependence on oil imports	(%)	33	25	59
Oil's share of electricity generation	(%)	10	5	30

[1] South Europe: Italy + Greece + Spain + Portugal.

Source: Eurostat.

Table 3

EUR 12: Oil consumption (1987)
Breakdown by product

	EUR 12	North Europe	South Europe[1]
Petrol	20	21	14
Kerosene + jet fuel	5	5	4
Diesel	14	12	14
Gas oil	20	23	14
Fuel oil	14	12	26
Others	16	16	16
Bunker fuel	6	6	6
Consumption in refineries	5	5	6
Total	100	100	100

[1] South Europe: Italy + Greece + Spain + Portugal.

Source: Eurostat.

After this brief look at the general pattern, the next stage is to examine the structure of the refining industry and trade in refined oil products in the two regions and then look into the problems which completion of the internal energy market could pose.

Structure of the refining industry

While total primary distillation capacity stands at 212 Mt in the southern Member States and 380 Mt in the north, in 1987 demand for petroleum products totalled no more than 130 Mt in the south and only just over 300 Mt in the north.

What is more, the northern Member States have a far higher proportion of complex refineries (83%) than the south (69%) but the south has a higher proportion of semi-complex and simple refineries (see Figure 1).

Figure 1

EEC refining capacity at 1.1.1988 complexity of refineries

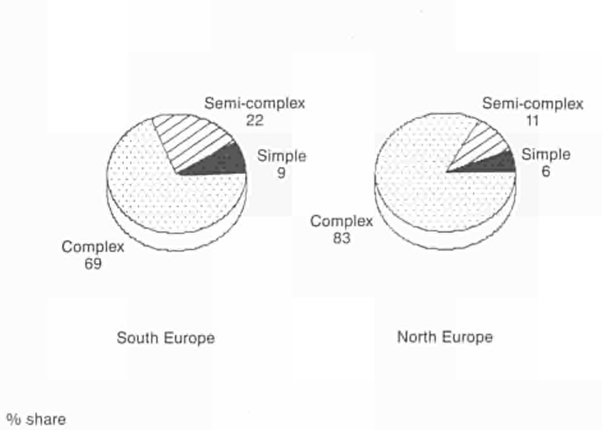


Figure 2

EEC reduction in primary capacity 1980-88

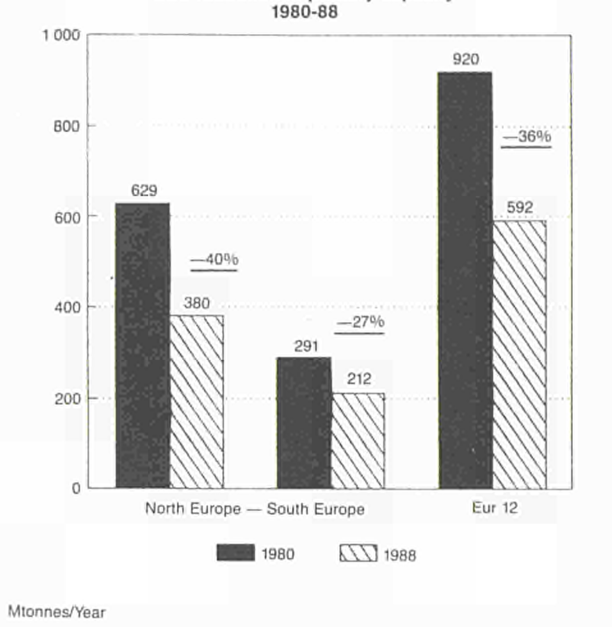


Figure 2 charts these distillation capacity closures. In the Community as a whole, 36% of the capacity available in 1980 had been shed by 1988. Over the same period capacity fell from 629 Mt to 380 Mt, or 40%, in the north, but by just 27% in the south. This raises the question whether the capacity-shedding in the south has kept pace with the current constraints on the refining industry throughout the Community. The evidence set out below suggests that it has not and that determined further rationalization is needed, particularly in southern Europe.

Conversion capacity

In the north, conversion capacity, expressed in terms of catalytic cracking equivalent, increased by almost half from 65 Mt/year in 1980 to 97 Mt/year in 1988. Coinciding with the sharp fall in total distillation capacity in the north, this pushed conversion capacity up to 26% of primary distillation capacity, compared with just 10% in 1980.

In the south, conversion capacity rose from 16 Mt/year to 46 Mt/year over the same period, a far more vigorous relative growth rate than in the north. However, even today the share of distillation capacity accounted for by catalytic cracking equivalent in the south (22%) still lags behind the Community average (24%). These figures are the fruit of the investment in conversion capacity in the south and, to a certain extent, of the different primary capacity closure rates in the two halves.

Refining balance for the Community as a whole

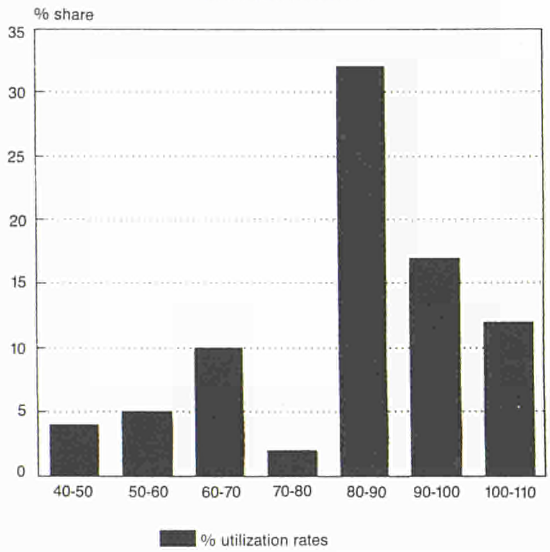
In 1980, north and south were almost neck and neck with an average primary capacity utilization rate of 62% for the Community as a whole, 58% in the south and 64% in the north.

By 1987 there had been a marked improvement in the average utilization rate, but the gap between north and south had widened considerably. The north had climbed up to a relatively comfortable utilization rate of 83%, whereas the south was up to just 71%. Unfortunately, the southern Member States still lag behind the north in terms of both profitability and adjustment of capacity to demand.

Figures 3 and 4 illustrate this particularly striking form, by classifying refining capacity by utilization rate in 1987. In the north of the Community the utilization rate was below 50% for just under 5% of the refining capacity, between 50% and 60% for another 5%, between 60% and 70% for 10% of the refineries but between 80% and 90% for the vast majority comprising some 30% or more of the capacity. Roughly 15% of the north's refineries achieved utilization rates of close to 100%. Just over 10% surpassed 100%.

Figure 3

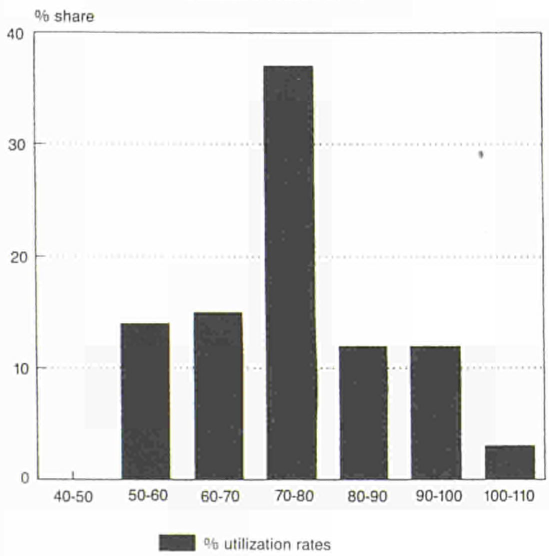
Refining capacity, 1987, North Europe
Utilization rates in %



North Europe: B, DK, DE, FR, UK, IRL, NL

Figure 4

Refining capacity, 1987, South Europe
Utilization rates in %



South Europe: I, E, GR, P.

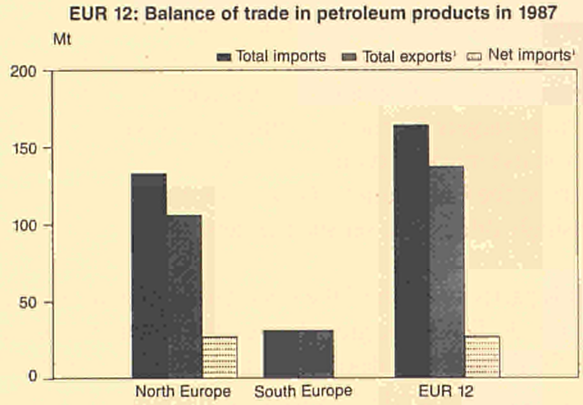
The situation was less rosy in the south, where the Gaussian curve was much further to the left. There the vast majority of refining capacity attained utilization rates of between 70 and 80%. Only 27% broke through the 80% barrier, compared with 60% in the north.

Foreign trade in refined products

Figure 5 illustrates the Community's total imports, total exports and net imports, including intra-Community trade but excluding feedstock movements.

Figure 5

EUR 12: Balance of trade in petroleum products in 1987



Source: Eurostat. [1]Including intra-Community (EUR 12) trade.

Until 1985 both the north and south were net exporters. In 1985 the north became a net importer, while the south remained a net exporter. As the table shows, the southern Member States as a whole are now in equilibrium.

However, the situation could change once Spain, Portugal and Greece relax their restrictions on imports from other Community countries.

Action by the Community concerning the refining industry

In May 1988 the Council approved a Commission Working Document[1] on the Internal Energy Market which took stock of all the existing or potential obstacles to the free movement of energy in the Community. Many of the long list of obstacles facing the oil industry could have a far-reaching impact on the refining industry. Top of the list came the monopolies in Greece, Portugal and Spain which are just beginning to be broken up. It is not easy for countries with

1 See *Energy in Europe* Special Issue on the internal market.

such a long tradition of State control over what they see as a strategic sector to switch to a more open, free-market philosophy. Nevertheless the Spanish Government in particular has already taken steps in this direction, though only time will tell whether the system now being introduced will fit in smoothly with the principles set out in the EEC Treaty. By contrast, the Greek system remains an extremely tricky problem.

Clearly, the removal of other obstacles such as the diverging tax burdens, technical standards and administrative procedures should in turn help to improve the conditions in which the refining industry operates.

For the last 10 years or so the Community's policy on the refining industry has been built around the need to trim refining capacity down to the new levels of demand. To achieve this, the Commission has regularly set capacity-shedding targets for the Community as a whole, most recently in its latest report on the oil market and the refining industry in the Community.[2] Now, however, it is becoming increasingly difficult to set such targets.

This is partly because of the uncertainties about consumption trends. Economic growth rates, the dollar/ecu exchange rate, OPEC unity, crude-oil prices and inter-fuel competition too are all unknown factors which can combine in different ways.

To make matters worse, the companies' strategies, the regional and social hardship caused by closures and certain governments' concern to maintain long-term security of supply without becoming overdependent on other countries all militate increasingly against shutting down surplus refineries.

Recently the Council, acting on a proposal from the Commission, stated that the industry was responsible for all decisions concerning refinery closures, investment in conversion capacity and other rationalization measures. It is the governments' duty to avoid creating any obstacle or artificial incentive to the action taken by the companies, so that industrial and commercial considerations alone shape the restructuring process. The Commission's role is to check that the process goes smoothly and to monitor the wider international ramifications.

This raises the question of imports from non-Community countries. The Council wants the Community market to remain open to imports from non-Community countries, subject to two conditions:

(i) The Community's industrial partners, particularly the USA and Japan, must adopt an equally open policy. The Reagan Administration always resisted protectionist pressures. If the new Administration were to change course, the Community would have to display a firm commitment to retaining the free-trade policy pursued hitherto. Impressive progress has been made on the Japanese side, under combined pressure from the USA and the Community. The next question will be whether Japan will still be as open to foreign suppliers when it embarks on the next stage of its reorganization of the refining industry, for which it recently gave the go-ahead.

(ii) The crude-oil producers now entering the market as exporters of refined products must maintain a reasonable attitude both to investment and to trading practices. The best way to achieve this is to establish and maintain closer ties with them. This is just one of the possibilities opened up by the June 1988 agreement with the Gulf Cooperation Council, for example.

One other important point is the impact of environmental protection standards on refineries. Some governments, particularly in the northern Member States, have been complaining that they are at a competitive disadvantage *vis-à-vis* the southern Member States with less stringent environmental protection standards. In practice, however, the situation is less clear-cut since environmental protection costs are only one of the many ingredients of competitiveness. Others such as financial charges, labour costs, siting, access to crude supplies, transport distances, etc. can affect refineries' competitive position perhaps even more than environmental protection costs. What is more, even in countries with purportedly lax environmental standards the local authorities may impose other measures just as costly as those adopted in the 'tougher' countries. And it remains to be seen how effectively the countries with more stringent standards enforce them. Nevertheless, standards on the lead content in petrol, for instance, will soon be the same in the north and south of the Community. Based on the decisions already taken and the plans announced all the Member States will have to reduce the lead content to 0.15 g/l by the end of 1991.

Conclusions

The future of the refining industry concerns every Community Member State.

The industry has clearly done more to adapt in the north of the Community than in the south. Generally, substantial overcapacity, with plant far outstripping demand, persists in

---

2 COM(88) 491 final, 23.9.1988.

the southern Member States. Much as it is to be hoped that this half of the Community will rise to the challenge, the technocratic drive for harmonization must not overlook the unique constraints and conditions in each country and the need to strengthen the weaker economies in the Community: all these factors must be taken into account during the adjustment in the southern Member States.

At the moment the economic climate is favourable for the southern Member States. However, this must not blind them to the future. Whatever the differences between them north and south both have a role to play in supplying the Community market. A series of factors, not least the current economic climate and the prospect of a single Community energy market, will force refineries in north and south alike to take full account of the conditions in which they operate. They are set to grow increasingly similar. Sooner or later the current differences will have to be removed in order to preserve a healthy, competitive refining industry serving consumers everywhere in the Community.

Energy prices: statistical analysis of end-consumer prices in the European Community

1. Introduction

This report contains a statistical analysis of end-consumer prices for 16 energy products.

More specifically, an attempt is made to answer the following question: 'What price differences are there between the Community countries and how have they evolved over the years?'

To answer this question the analysis is divided into two parts:

(a) The first part examines the differences from one country to another for each of the 16 products.

(b) In the second part the differences between the prices of the products competing on a given market are analysed for the domestic sector and the industrial sector.

The statistical methods used are deliberately fairly simple with a preference for graphs rather than tables.

Table 1

Basic data — Main features

Product	Code	Unit	Countries	Obs/ country	Tot. Obs.
A. Petroleum products					
1. Residual fuel oil (HSC)	RFO	Tonne	10	17	170
2. Heating gas oil	HGO	1 000 l	10	17	170
3. Diesel	DIE	1 000 l	10	17	170
4. Premium petrol	PRE	1 000 l	10	17	170
B. Coal					
5. Domestic coal	DCO	TCE	7	14	91
6. Industrial coal	ICO	TCE	5	16	81
C. Electricity					
7. Domestic - 1 700 kWh/year	DE1	kWh	10	10	98
8. Domestic - 3 500 kWh/year	DE2	kWh	10	10	99
9. Domestic - 13 000 kWh/year	DE3	kWh	9	10	88
10. Industrial - 1.25 GWh/year	IE1	kWh	10	10	99
11. Industrial - 10 GWh/year	IE2	kWh	10	10	99
12. Industrial - 24 GWh/year	IE3	kWh	10	10	92
D. Gas					
13. Domestic - 16.74 GJ/year	DG1	GJ (NCV)	9	9	80
14. Domestic - 125.6 GJ/year	DG2	GJ (NCV)	9	9	81
15. Industrial - 41 860 GJ/year	IG1	GJ (NCV)	7	9	61
16. Industrial - 418 600 GJ/year	IG2	GJ (NCV)	6	9	53

Source: Bulletin of energy prices, DG XVII, No 1-1987.

2. The data used

The data on which this analysis is based were taken from the *Bulletin of energy prices* which the Directorate-General for Energy (DG XVII) publishes twice a year. Generally speaking, the figures relate to January and July of each year.

Further information about definitions, sources, units and methods used to compile these time series can be obtained from the annexes to the Bulletin.

The 16 products covered comprise four types of petroleum products, two categories of coal use, six electricity categories and four natural gas categories.

Depending on the data available, the period studied ranges between January 1979 and January 1987 (17 observations). The analysis only concerns 10 countries as figures for Spain and Portugal are only available from January 1986.

Table 1 summarizes the main features of the data.

There are generally three time series for each product and each country:

(a) prices excluding tax (ET),
(b) prices including tax, but excluding VAT (EVAT), and
(c) prices including all tax (IAT).

As the basic data are supplied in national currency per specific unit, they are expressed here:

(a) either in constant 1984 ecus per specific unit,
(b) or in constant 1984 ecus per GJ of useful energy.

The price indices and exchange rates are those of the Statistical Office of the European Communities. The coefficients published in Annex II to the Bulletin have been used to convert supplied energy into useful energy.

3. Comparison between the prices in the different countries

3.1 General

In order to compare the level and trend of prices in the different countries, attempts are made to answer three questions:

(a) The first question concerns the average prices over the entire reference period:

Are there significant differences in the average price levels for individual products? If so, are there two or more subgroups of countries where prices are similar?

(b) The answer to the above question does not provide any information about the trend of price relativities over time. Consequently, we have formulated a second question about the price trend over the same period:

Is there a trend towards convergence over time or, conversely, is there a tendency for prices to diverge?

(c) The final question concerns the behaviour specific to each country.

What is the price trend in each of the 10 countries in relation to the Community average?

3.2 Methods

An appropriate statistical method has been used in order to answer each of these questions:

(a) To compare the average price levels, an analysis of variance has been carried out. This is a standard method which makes it possible to test the hypothesis that the mean of several samples is equal, and thus to verify whether these samples come from populations with the same mean. In this case the samples are the prices per product and per country, expressed in constant 1984 ecus per specific unit. The analysis of proximity was carried out using Scheffé's method with an alpha-error of 0.05.

(b) To examine convergence, a 'convergence index' has been estimated for each product. From among the various possible methods one has been chosen which is fairly straightforward and is based on linear regression analysis.

This index is negative if there is convergence and positive if there is divergence. What is more, one can test whether it is significantly different from zero using 'Student's t-test'. The value of this index is independent of the units used and hence is comparable from one product to another.

(c) To examine the behaviour specific to each country an average price has been calculated for EUR 10, weighted by the level of consumption in 1984, and then an index of relative prices for each country has been calculated (base 100 for EUR 10).

The development of relative prices has been set out in graph form and has been approximated by a second-degree trend.

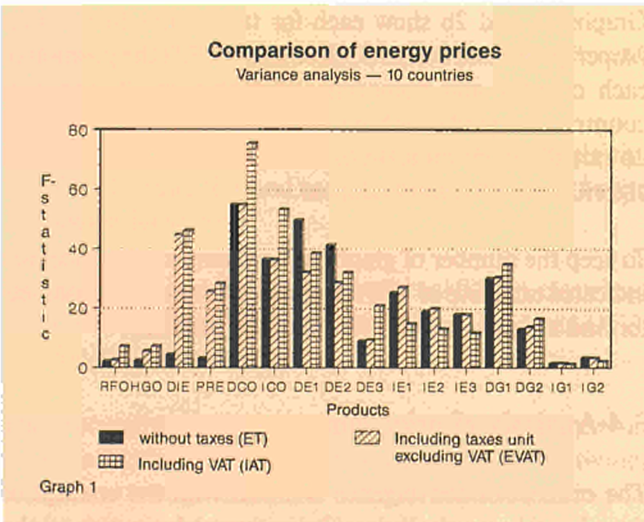
3.3 Differences between the average price levels in the 10 countries

The results of the variance analysis, expressed in terms of the F-statistic, are set out in Table 2 and Graph 1.

Table 2

Comparison of energy prices
Variance analysis

Product	No Country	No Tot. Obs.	F-statistic (Associated probability) Price ET	Price EVAT	Price IAT
A. Petroleum products					
1. RFO	10	170	1.9952	2.4947	7.0512
			(0.0430)	(0.0107)	(0.0)
2. HGO	10	170	2.2836	5.5165	7.1530
			(0.0195)	(0.0)	(0.0)
3. DIE	10	170	4.4085	44.6279	46.0360
			(0.0)	(0.0)	(0.0)
4. PRE	10	170	3.0925	25.6146	28.2966
			(0.0019)	(0.0)	(0.0)
B. Coal					
1. DCO	7	91	54.7968	54.7968	75.4601
			(0.0)	(0.0)	(0.0)
2. ICO	5	81	36.3402	36.3402	53.2958
			(0.0)	(0.0)	(0.0)
C. Electricity					
1. DE1	10	98	49.6924	32.0824	38.5004
			(0.0)	(0.0)	(0.0)
2. DE2	10	98	41.3137	28.6691	31.9953
			(0.0)	(0.0)	(0.0)
3. DE3	9	88	8.9728	9.3334	20.8831
			(0.0)	(0.0)	(0.0)
4. IE1	10	99	25.2992	27.0778	14.7405
			(0.0)	(0.0)	(0.0)
5. IE2	10	99	18.9933	19.9396	12.9935
			(0.0)	(0.0)	(0.0)
6. IE3	10	92	17.9902	17.9217	11.6746
			(0.0)	(0.0)	(0.0)
D. Natural gas					
1. DG1	9	80	30.1738	30.4817	34.8751
			(0.0)	(0.0)	(0.0)
2. DG2	9	81	12.9482	13.7843	16.5040
			(0.0)	(0.0)	(0.0)
3. IG1	7	61	1.5253	1.4996	1.2341
			(0.1876)	(0.1959)	(0.3036)
4. IG2	6	53	3.3770	3.2773	2.1597
			(0.0109)	(0.0128)	(0.0746)



Graph 1

For the purpose of interpreting the results, it is important to remember that to reject, with a 95% probability, the hypothesis that the means are equal, the F-statistic must be greater than 1.95 in the case of 10 countries and 170 observations and greater than 2.40 in the case of 6 countries and 53 observations. For a 99% probability the corresponding values are 2.45 and 3.45. Table 1 also indicates the probabilities associated with each F-value. This variable indicates the probability of obtaining an F-statistic at least as large as what would be obtained if the mean of each population was equal. In practice if this probability is greater than 5% the hypothesis of equality of the means cannot be rejected.

It emerges from an examination of the results that there are only two cases in which the average prices do not differ significantly from one Community country to another: certain petroleum products (residual fuel oil and heating gas oil, excluding tax) and natural gas for industry.

The detailed situation for each product is as follows:

(a) Petroleum products: the average prices, excluding tax, do not differ a great deal. However, after tax there are significant variations, particularly as regards motor fuels (diesel and premium petrol).

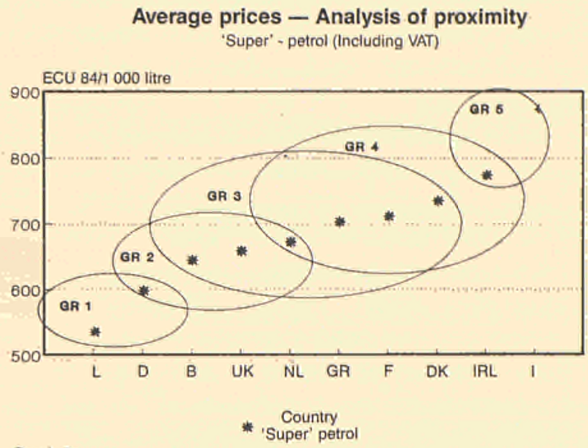
(b) Coal: this is the product for which the differences are the most marked.

(c) Electricity: there are also considerable differences in the case of electricity. They increase the smaller the consumption category (DE1 and IE1).

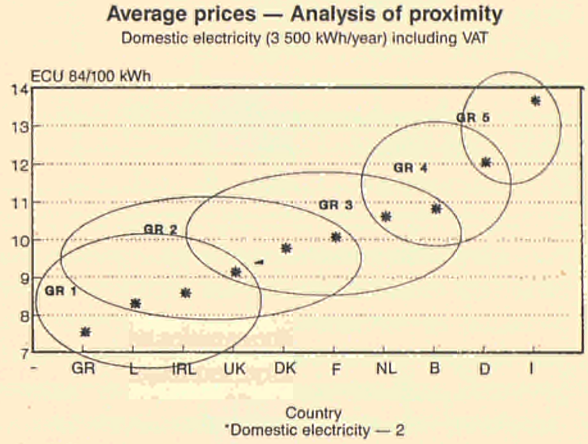
(d) Natural gas: there are considerable differences in the domestic sector.

Graphs 2a and 2b show each for two of the 16 products ('super' petrol and domestic electricity 'DE2') the position of each country and homogeneous subgroups. A group of countries is regarded as homogeneous if their average prices do not differ by more than a value calculated using the algorithm of proximity adopted.

To keep the number of graphs to a minimum, the prices are indicated exclusive of VAT for products for the industrial sector and inclusive of VAT for all other products.



Graph 2a



Graph 2b

3.4 Analysis of price convergence

The concept of convergence is linked with the concept of time. In other words, the results may vary depending on the period considered. In particular, it is highly probable that the results would not be the same if the period examined were shorter.

Also, while the concept of convergence is comparatively clear-cut in the case of two or three countries, it becomes impossible to visualize when taking 10 countries together which between them form no less than 45 pairs.

The results of the analysis are set out in Table 3 and Graph 3. In the case of petroleum products and electricity (data for 10 countries available), the calculations have been done twice: once for EUR 10 and once for EUR 9, since Greece was not yet a Community member at the beginning of the period considered.

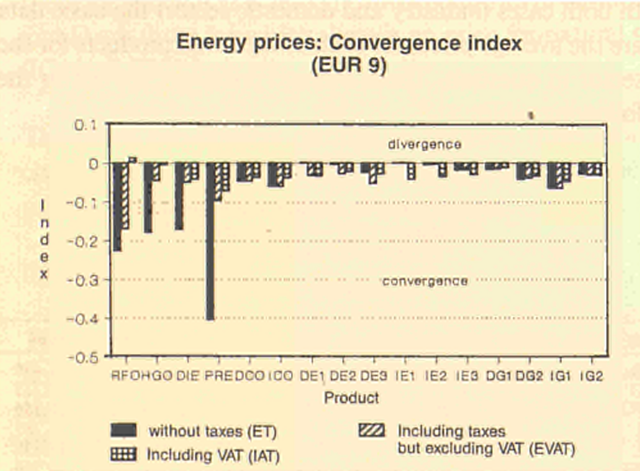
A negative index indicates convergence and a positive index indicates divergence. Also, a value of Student's t-statistic of less (in absolute terms) than 1.97 indicates with a probability of 95% that the hypothesis that the estimated index does not differ significantly from zero cannot be rejected. For a 99% probability the corresponding value is 2.34.

Table 3

Comparison of energy prices
Conversion index EUR 9 and EUR 10

	EUR 10 Price ET	EUR 10 EVAT	EUR 10 IAT	EUR 9 Price ET	EUR 9 EVAT	EUR 9 IAT
A. Petroleum products						
1. RFO	−0.27725 (−5.04)	−0.23189 (−4.44)	−0.04738 (−1.01)	−0.22912 (−4.42)	−0.17279 (−3.81)	+0.01254 (+0.28)
2. HGO	−0.22607 (−4.34)	−0.14017 (−2.61)	−0.06342 (−1.33)	−0.18177 (−3.70)	−0.04871 (−1.05)	−0.00826 (−0.19)
3. DIE	−0.17882 (−4.13)	−0.05439 (−2.35)	−0.04141 (−1.97)	−0.17406 (−4.00)	−0.05286 (−2.39)	−0.04520 (−1.96)
4. PRE	−0.24364 (−4.42)	−0.11992 (−3.26)	−0.08834 (−2.58)	−0.40686 (−5.61)	−0.09992 (−2.59)	−0.07492 (−2.13)
B. Coal						
1. DCO				−0.05057 (−2.04)	−0.05057 (−2.04)	−0.04024 (−1.95)
2. ICO				−0.06343 (−1.42)	−0.06343 (−1.42)	−0.04101 (−1.15)
C. Electricity						
1. DE1	−0.00863 (−0.62)	−0.03386 (−1.97)	−0.03791 (−2.37)	−0.00283 (−0.20)	−0.03518 (−1.97)	−0.03644 (−2.12)
2. DE2	−0.01291 (−0.75)	−0.03128 (−1.51)	−0.02972 (−1.52)	−0.00627 (−0.34)	−0.03067 (−1.35)	−0.02579 (−1.17)
3. DE3	−0.04015 (−1.53)	−0.06440 (−2.26)	−0.03837 (−1.75)	−0.02740 (−1.04)	−0.05616 (−1.93)	−0.03103 (−1.36)
4. IE1	−0.00781 (−0.37)	−0.00746 (−0.36)	−0.05530 (−2.09)	−0.00304 (−0.15)	−0.00251 (−0.13)	−0.04536 (−1.75)
5. IE2	−0.00905 (−0.40)	−0.00844 (−0.38)	−0.04635 (−1.67)	−0.00735 (−0.35)	−0.00626 (−0.30)	−0.03826 (−1.44)
6. IE3	−0.02538 (−1.01)	−0.02468 (−0.96)	−0.04511 (−1.51)	−0.02161 (−0.93)	−0.02029 (−0.85)	−0.03307 (−1.20)
D. Natural gas						
1. DG1				−0.01997 (−1.21)	−0.01815 (−1.09)	−0.01498 (−0.94)
2. DG2				−0.04550 (−1.96)	−0.04265 (−1.87)	−0.03712 (−1.72)
3. IG1				−0.06823 (−1.64)	−0.06910 (−1.66)	−0.05102 (−1.29)
4. IG2				−0.03133 (−0.89)	−0.03378 (−0.96)	−0.03483 (−0.96)

In brackets: the Student's t-statistics.



Graph 3

It emerges from an examination of the table that with one exception all the prices tend to converge. However, this overall result needs to be differentiated since of the 78 indices estimated only 23 are significant with an alpha-error of 0.05 (with 95% probability).

The trend towards convergence is very marked in the case of petroleum products excluding tax. This result combined with the former indicates that in the case of the market for petroleum products we are moving towards a situation in which the prices excluding tax in the various countries are likely to become increasingly close to one another. However, taxation (especially VAT) offsets this phenomenon.

In the case of coal and gas there is a slight trend towards convergence, but it is fairly slow. In the case of electricity, the results indicate that the trend towards convergence is very slight and virtually non-existent in the case of industry.

3.5 Trend by country

In order to get a better idea of the convergence trends described above, it is necessary to examine the behaviour specific to each country and for each product. Simple graphs were used to show the trend in price relativities in relation to the Community mean. The graphs are based on prices excluding tax in the case of products for industrial use and prices including VAT in the case of all other products. It is again apparent from these graphs that the concept of convergence is not an easy one to define. The trends are far from being linear and there are often sudden breaks in the trend of price relativities.

4. Comparison of the prices of competing products

4.1 General

The relationships between the prices of products for the same markets were examined for:

(a) residual fuel oil (RFO), industrial coal (ICO), electricity (IE1, IE2 and IE3) and natural gas (IG1 and IG2) for the industrial sector;

(b) heating gas oil (HGO), domestic coal (DCO), electricity (DE1, DE2 and DE3) and natural gas (DG1 and DG2) for the domestic sector.

The relationships between these prices cannot be analysed in the same way as above, because the trend of price relativities depends to a large extent on external factors, and in particular the price of crude oil. Clearly, for example, the question of the convergence or otherwise of the prices of competing products in a country or in the Community as a whole cannot be posed in the same terms as above. It is interesting, however, to derive information, for each period, about the relativities as regards the prices of potentially interchangeable products.

That is why the study was confined to two points:

(a) an examination, in the form of graphs, of the price trend in each country, and

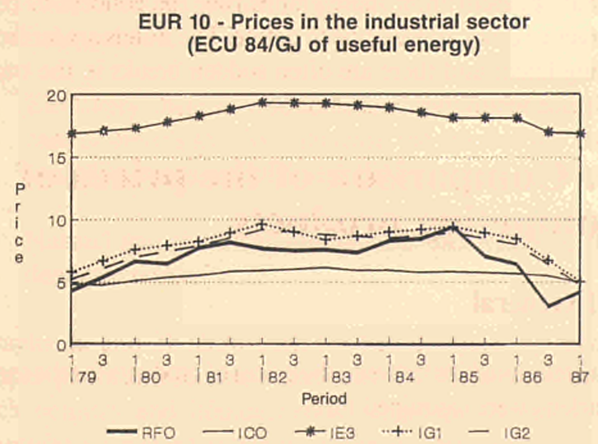
(b) an attempt to classify the 10 countries on the basis of the different types of behaviour of relationships between average prices in the period under study.

For a better comparison of the prices of different energy products they are expressed in terms of useful energy (constant 1984 ecus per GJ of useful energy).

4.2 Price trend by country

A. Industry

Graph 4 shows for EUR 10 the trend in the prices of products for industry.

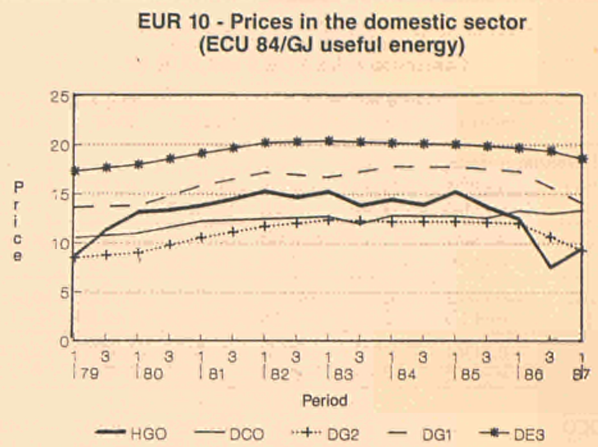


Graph 4

In most of the countries the prices of fuel oil, coal and gas are very close and to a large extent they vary according to the import prices. Electricity prices, on the other hand, are markedly higher despite a slight downward tendency in certain countries since 1982/3.

B. Domestic sector

Graph 5 shows for EUR 10 the trend in the prices of products for the domestic sector.



Graph 5

On the basis of these graphs it would be possible to come to virtually the same conclusions as above. However, in this sector electricity prices (for the higher consumption range) are not as different from the prices of the other products and often they are close to the prices of natural gas in the lower consumption range.

4.3 Classification of countries

The 10 countries can be classified on the basis of their average prices for each of the two sectors over the entire period examined (1 January 1979 to 1 January 1987).

The main value of such an analysis is that it makes it possible to identify two or three groups of countries in which price relativities behave in much the same way.

The cluster analysis was done using hierarchical classification and the nearest neighbour algorithm.

In both cases (industry and domestic sector) the basic data are the average prices for each of the seven products for the sector in question. These average prices are set out in the following tables:

Table 4

Average prices by country and by product
(1 January 1979 — 1 January 1987)
(ECU 84/GJ useful energy)

A. Industry — EVAT

	RFO	ICO	IG2	IG1	IE3	IE2	IE1	Mean
B	5.886	5.440	6.842	7.764	16.954	19.836	23.989	11.436
D	6.812	6.219	9.032	9.158	17.924	23.075	28.512	13.312
F	6.610	5.087	6.363	7.124	14.435	16.779	20.122	10.166
I	6.701	6.699	7.386	7.801	20.088	23.936	27.824	13.287
L	6.191			7.383	14.457	16.904	21.877	12.538
NL	6.832		6.369	6.846	20.511	23.226	27.436	14.566
DK	6.675				10.158	14.029	15.154	10.876
IRL	8.428				22.271	24.601	29.066	19.206
UK	7.680	5.013	8.143	8.475	19.607	21.478	24.126	12.605
GR	6.594				19.068	21.368	24.131	15.755
Mean	6.841	5.684	7.341	7.600	18.046	20.515	24.225	13.092

(Table 4 contd.) **B. Domestic sector - IAT**

	HGO	DCO	DG2	DG1	DE3	DE2	DE1	Mean
B	10.925	12.435	11.483	19.029	21.143	41.760	53.848	22.942
D	12.029	12.320	12.833	20.830	18.489	46.470	53.962	23.844
F	13.518	15.279	12.517	19.912	21.941	38.868	48.314	23.225
I	14.926	16.520	13.199	16.110		52.666	31.091	23.086
L	10.647		9.426	17.193	16.072	32.077	40.869	19.902
NL	12.712	13.794	9.622	11.731	24.652	40.965	46.989	21.970
DK	15.818		21.860	28.916	25.193	37.713	43.792	27.582
IRL	13.095	9.161	19.838	28.550	18.790	33.155	42.704	22.098
UK	12.840	11.672	8.549	13.394	16.029	35.292	46.737	19.847
GR	12.243				16.887	29.147	34.163	21.134
Mean	12.875	13.026	13.259	19.502	19.989	38.909	44.384	22.587

(a) Industry

The cluster analysis for industry has been made for three alternative subgroups: (i) all 10 countries, (ii) the five countries for which the seven prices are available, and (iii) the seven countries for which the prices for RFO, IG1 and electricity (IE1 to IE3) are available.

The results are set out in the following table:

Table 5

Industry: Results of the cluster analysis

	10 countries 7 prices 4 groups	5 countries 7 prices 3 groups	7 countries 5 prices 3 groups
Group A	D, F, I, NL B, UK	D, I, NL	D, I
Group B	L	F	F, L
Group C	IRL, GR	B, UK	B, UK
Group D	DK		

The first classification (10 countries) is not particularly significant since it is based on the existence or otherwise of a price: the four countries excluded from the first group are those for which IG2 is zero, the three countries in Groups C and D are those for which there is no price for natural gas (IG1 and IG2 zero), etc.

The other two clusters distinguish between three groups characterized in particular by the position of electricity prices.

(b) Domestic sector

The cluster analysis for the domestic sector has also been done on the basis of three alternative subgroups, following the same principle as above: (i) all 10 countries, (ii) six countries for which the seven prices are available, and (iii) the eight countries for which the prices for HGO, gas and electricity (DE1 and DE2) are available.

The results are set out in the following table:

Table 6

Domestic sector: Results of the cluster analysis

	10 countries 7 prices 5 groups	6 countries 7 prices 4 groups	8 countries 5 prices 4 groups
Group A	D, F, NL, B, UK	D, F, B	D, F, B
Group B	I	NL	NL
Group C	L	UK	UK, L
Group D	IRL, DK	IRL	IRL, DK
Group E	GR		

As before, the first cluster is based mainly on the existen or otherwise of a price.

Group A is in the centre, Group B (Netherlands) characterized by the low price of gas and the high price electricity, and Groups C and D are at the two extremes f the price of gas.

5. Conclusions and summary

The main points of this analysis may be summarized follows:

(a) The average prices for the various energy products st differ fairly considerably from one country of the Cor munity to another. The main exceptions to this rule a the prices of certain petroleum products (residual fu oil and heating gas oil) excluding tax, and the price gas for industry (Graphs 1 and 2).

(b) A general trend towards price convergence is appare over the period 1979-87. However, while this trend significant in the case of petroleum products it is i significant in the case of electricity (Graph 3).

(c) This overall assessment conceals differences i behaviour peculiar to certain countries and certai products.

(d) The trends in the prices of products for the sar markets (industry or domestic sector) are influenced a large extent by the prices of imported products, despi the differences observed from one country to anoth (Graphs 4 and 5).

(e) Nevertheless, in each sector it is possible to identify few subgroups of countries characterized by simil behaviour with regard to the average relative prices potentially interchangeable products.

Public opinion in the European Community on energy in 1987

In 1982 the Commission of the European Communities' Directorate-General for Energy ordered its first opinion poll on questions relating to energy. Further surveys followed, one in 1984 and another in 1986, progressively building up a clearer picture and greater understanding of Europeans' opinions and attitudes in this field.

'Faits et opinions', the public opinion pollsters, have produced a detailed report on a survey they conducted for the Commission amongst 11 600 citizens in the 12 Member States in the autumn of 1987.

'Public opinion in the European Community on energy in 1987' is the fourth survey in the series. It is based on the same questionnaire used in 1984 in order to gauge the extent to which European public perception of energy issues has changed in three years in an economic and political climate which has also changed considerably over that period, particularly in 1986 — the year of the Chernobyl nuclear accident.

All the questions presented in this report have been asked in the past, many of them on several occasions. In the case of some questions, dealing with nuclear energy, the first answers go back to 1978, when this subject was approached in more general studies. These questions were automatically included in all subsequent surveys, so that today analysts have data from five separate points in time spread over a nine-year period, providing a powerful tool for understanding the shifts which have taken place in European public opinion in the course of nearly a decade on such essential matters as the building of nuclear power stations.

The general picture

This survey, carried out in autumn 1987, explores a whole series of questions relating to the key energy issues, as they might be put to any European citizen: the gravity of the situation in the respondent's country, independence from foreign sources of supply, consumer behaviour, attitudes to energy policy and, finally, the public's assessment of each individual source of energy and of nuclear energy in particular.

The 1986 survey showed the major impact on European opinion of a number of things which happened that year, in particular the fluctuations in the price of oil and the Chernobyl nuclear accident. The main trends which emerge from this new survey show that some of those shifts in opinion are still with us, while others are clearly fading.

Certainly, the level of anxiety about energy problems in general, which was already slightly lower in 1986, has fallen much further since then. Similarly, opposition to nuclear energy, which showed a considerable increase the previous year, remains very widespread. Europeans are increasingly fearful of nuclear hazards. On the other hand, the keen anxiety about pollution seems to have decreased somewhat and the European public today takes the view that the priority for any energy policy should, above all, be to achieve greater independence from imported energy supplies.

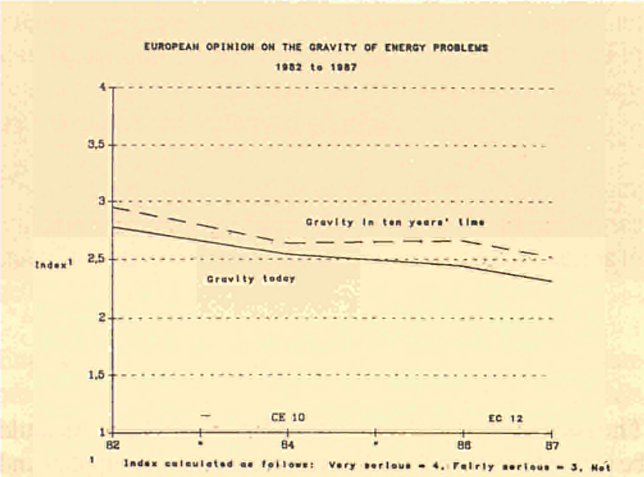
Public perception of the energy situation

As the oil crisis years recede into the past, Europeans appear less concerned by energy problems: in 1987, for the first time, most people were no longer anxious about the current situation in their country and nearly one in every two Europeans (49%) expressed calm confidence in this respect.

However, although Europeans are clearly recovering their optimism, not all their fears have been allayed and, though less numerous than in the past, many Europeans (45%), Greeks and Italians in particular, are still worried about the future and believe that their country will be facing a serious energy problem in 10 years' time. It should also be noted that the European public seems well aware of the vulnerability of some sources of energy. In this respect, several parts of the world are perceived as unreliable suppliers of energy to the countries of the European Community. This is particularly true of central and southern Africa. Western Europe, the United States of America and Canada, on the other hand, have a good image and the Europeans therefore primarily trust western producers to supply their energy requirements.

Since 1984, moreover, European opinion on the security of the supplies obtained from various parts of the world has tended to harden: in general, those parts of the world previously considered reliable suppliers are now viewed with even greater confidence and, conversely, those which were regarded as unreliable appear even more so. Two exceptions should nevertheless be noted: the USSR and the countries of Eastern Europe — whose image, although still somewhat negative, has improved — and Australia, which, on the contrary, is seen less positively today than three years ago.

On the whole, Europeans seem well informed about some of the key aspects of the energy situation in their country. This, at least, is a conclusion which can be drawn from their fairly accurate assessment of how far their country is self-sufficient in energy. It should also be noted that their view of short-term electricity consumption trends in their own country generally agrees with the experts' assessment of the situation between now and 1995.

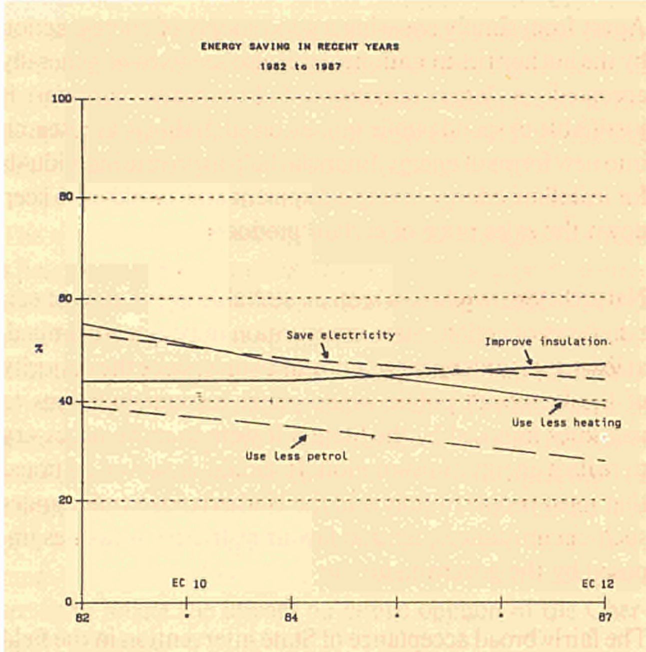


[1] Index calculated as follows: Very serious = 4, Fairly serious = 3, Not very serious = 2, No problem = 1. "Don't knows" have been excluded.

Energy consumption

Possibily because they are more confident about the energy situation in their country, at all events Europeans seem more inclined to make use of the energy available to them. They clearly perceive that electricity consumption will continue to grow and although most of them think that a large amount of energy is wasted in their country, this does not seem to worry them unduly. This is confirmed by their energy-saving behaviour: in general, Europeans are taking fewer steps to save energy than was reported in the 1984 survey. Indeed, the only upward trend has been in expenditure on home insulation: action involving a special effort to cut back consumption, on the other hand, is being taken less frequently.

As regards the type of energy used, or preferred for use, certain shifts in opinion are also worth pointing out. The most important of these is the increased preference for gas for home heating and for cooking. This preference first appeared in the 1984 survey. Now even more households seem to be choosing gas: in the 10 countries for which a comparison is possible, gas heating gained eight penetration points while oil heating lost seven and gas cooking remains at a high level whereas the use of electricity for cooking is declining.



Energy policy

As in 1984, the European public clearly recognizes that the authorities have an important role to play in energy policy, not only nationally but also internationally, so that coordinated action can be taken by different countries. For example, Europeans consider it preferable that the decisions needed to ensure a good energy supply should be taken by the European Community as a whole rather than by each country individually.

It is true that this desire for coordinated action between the Member States is not specific to the field of energy: the survey shows that, when asked about such things as aid to the developing countries, the fight against unemployment, terrorism or defence problems, Europeans always look more favourably on joint action by the Member States than on action taken by individual countries. Nevertheless, the degree of support varies from case to case. In this respect, energy supply scores quite well, with 67% of answers in favour: in the league table of issues on which Europeans would like to see cooperation between governments it takes fourth place, behind environmental protection (74%), aid for the developing countries (76%) and the fight against terrorism (79%). It is therefore publicly perceived as a problem which should be tackled at Community rather than national level. Furthermore, European public opinion on this matter has not changed in the last three years: the desire for joint action has remained at the same level since 1984 and is expressed by the entire European population, whatever their nationality.

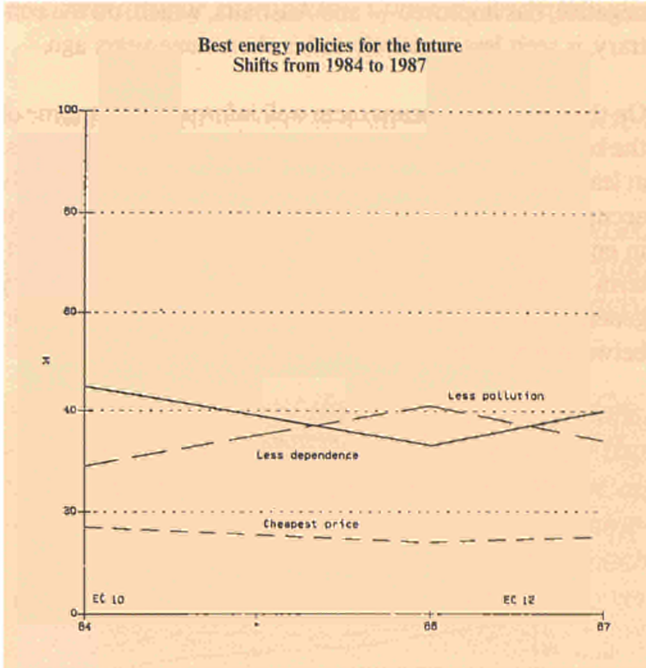
Apart from simply ensuring a good supply of energy, action by the authorities at national level also seems to be generally accepted: a large majority of Europeans consider it justifiable to spend public money on such things as research into new forms of energy, financial help to private individuals for installing energy-saving equipment and subsidies to keep down the sales price of certain products.

Nevertheless, while it is seen as desirable in the case of certain types of action, State intervention must remain limited, at least as regards energy-saving measures, since the majority of the European public would prefer recommendations to measures imposed by the State if it were to prove necessary to reduce energy consumption. It should, however, be noted that most people in Italy and the Netherlands would, under such circumstances, tend to favour restrictive measures imposed by the government.

The fairly broad acceptance of State intervention in the field of energy was already clearly apparent in 1984. Today, the citizens of Europe still accept State intervention even though the energy situation in their countries appears much less worrying. In other words, action by governments in this field seems to be accepted at a time of relative calm just as much as at times of crisis and greater anxiety.

Comparison of the results of the 1984 and 1987 surveys does not always show such stability. When it comes to the priorities for any future energy policy, European public opinion has, in fact, changed appreciably in the last few years. In 1984, one objective stood out as a clear priority: to achieve greater independence from foreign supplies of energy. In autumn 1986, on the other hand, the majority of Europeans — by a small margin — considered that the priority should be to combat pollution. A year later, the trend seems to have reversed once again: most Europeans today are again choosing to be as independent as possible of foreign supplies, although a large number still think it important to minimize pollution. Europeans thus appear less anxious about environmental problems than they were at the end of 1986, in the wake of the events which had occurred that year, although their anxiety has not completely disappeared.

This trend, in the Community as a whole, can be observed in most of the Member States. In the Federal Republic of Germany, Italy, Luxembourg and the Netherlands, however, most people still choose the priority of minimizing pollution, although this is a less popular answer than in 1986.



The two essential problems which Europeans believe should be tackled are, therefore, dependence on foreign supplies and pollution hazards. When asked to choose between the various possible solutions to the problem of energy supplies, most Europeans consider that the most appropriate course of action is to encourage the research needed to solve the technical problems of producing renewable forms of energy and to increase their use. This solution fits in well with the twin objectives of greater independence and less pollution.

At present, little use is made of such new forms of energy and, given the current state of research, they are unlikely to be developed on a large scale in the foreseeable future. Nevertheless, since they are perceived as a cleaner and more reliable source of energy, renewable resources enjoy a very good image with the European public, which is increasingly concerned by environmental issues. This situation is not new: European opinion in this field has hardly changed since 1982 and renewable energy increases its lead every year. Nuclear energy, which lost some ground in 1986, is looked on slightly more favourable this year but has not recovered its previous level of support. Energy saving and increased exploitation of energy from traditional sources are seen as possible, but usually secondary, solutions by sizeable minorities of the population.

Assessment of the various sources of energy

One essential aspect of the energy issue is, of course, the comparison of one energy source with another in terms of attractiveness. Three basic criteria were taken into account in the survey: price stability, security of supply and environmental impact.

Europeans' assessment of the various sources of energy has, in fact, hardly changed since 1984. As in the past, these various sources do not, on the whole, have a well-defined image in the mind of the European public. Only renewable energy sources are clearly perceived as the least polluting, whereas oil is indisputably still the least popular source of energy on all counts. Indeed, more than two thirds of all Europeans hope that, in future, the amount of oil used to generate electricity will be cut in order to reduce their country's dependence on foreign supplies.

However, the image of other energy sources is rather vague and none of them stands out clearly either in terms of price stability or security of supply, although natural gas seems to be increasing its lead gradually.

European opinion is, once again, very divided on the more precise issue of whether to use nuclear energy or solid fuels to meet increased demand for electricity in the future. In terms of price and security of supply, neither source of energy is seen as having a real advantage. On the other hand, a majority considers solid fuels preferable to nuclear energy when it comes to the environment. There is, however, a good deal of uncertainty on this question, from whatever angle it is approached, with roughly one European in five expressing no opinion. It is apparently not easy for many Europeans to assess the various sources of energy available in terms of objective criteria. Those who do express an opinion differ widely in their views on at least two of the three criteria.

In some countries, however, public opinion seems to be more clearly defined. In Greece and Spain, in particular, renewable energy sources are looked on most favourably from all points of view.

Nuclear energy

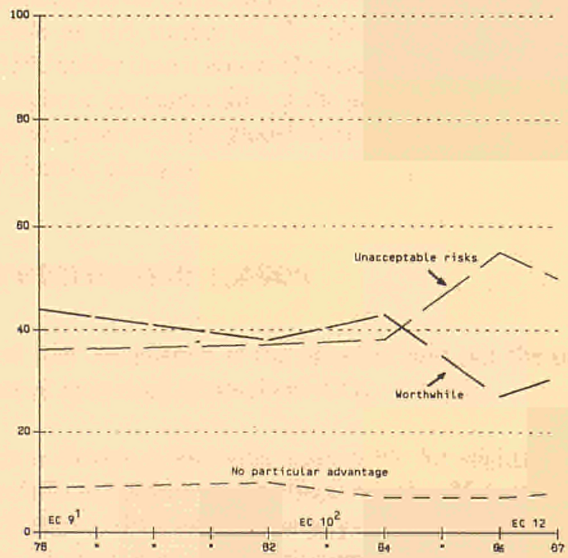
Since 1982 opinion polls on energy have paid particular attention to the attitude of Europeans towards nuclear energy. The answers given to certain questions repeated in every poll enable us, today, to measure the shift in public opinion on nuclear energy, which is still a hotly-debated subject.

The previous survey, in autumn 1986, showed a clear increase in anxiety about nuclear energy and far fewer Europeans in favour of its development. In some countries, this shift in public opinion seems to be a result of the Chernobyl nuclear accident but in others such as Denmark, Ireland, Italy, Luxembourg and the United Kingdom this movement had already begun several years earlier.

According to the new survey, opposition to nuclear power seems, in general, to have remained at this higher level in 1987: today, one in every two Europeans is opposed to the building of further nuclear power stations and only slightly more than three people in 10 are in favour of it.

The view thus expressed by the European public arises from a heightened sense of anxiety about the hazards presented by nuclear power stations. Three-quarters of the population still rank them amongst the most hazardous industrial installation though Europeans today seem to be much more concerned about the risks which they present. The most serious hazard is still thought to be the storage of radioactive waste. Radioactive emissions during the everyday operation of nuclear power stations take second place. However, the fear of a power station explosion, while still taking third place, more than doubled between 1982 and 1987. This certainly seems to reflect the impact on public opinion of the Chernobyl accident.

Public opinion on the development of nuclear power stations 1978 - 87



[1] Excluding Greece.
[2] Excluding Spain and Portugal.

In view of these anxieties, the argument that more nuclear power stations must be built if we are to avoid cutting our electricity consumption seems less and less credible. Indeed, since 1986, more people reject the argument than accept it.

However, it is recognized that the economic stakes are high since the possibility of electricity cuts is still perceived as a serious situation by a great majority of Europeans. The belief that nuclear power is essential to satisfy our ever-increasing energy requirements is fading, but is still widely held in France and Italy.

In general, of all Europeans, the French are the least hostile to nuclear power, followed by the British: in both these countries at least as many people consider the development of nuclear power stations worthwhile as that it is an unacceptable risk.

Summary

The survey included a whole range of questions relating to the major energy problems: the seriousness of the situation in the respective countries, dependence on imports, patterns of consumption, attitudes to energy policy, and, finally, attitudes to different energy sources, and nuclear power in particular.

A more specific study carried out in 1986 showed that the numerous events occurring in that year, including fluctuations in the price of oil and the accident at Chernobyl, had had a considerable impact on public opinion in Europe. The major trends revealed by the results of this new survey show that some of these developments persist today, whilst others have faded away.

It is clear that the slight decline, discerned in 1986, in concern about the general energy situation has since become more pronounced. However, hostility towards nuclear power, which had grown considerably the previous year, remained widespread and Europeans' fears in this area continue to grow. By contrast, concern about pollution seems to have diminished somewhat, and the people of Europe today believe that the major objective of energy policy must be to reduce dependence on imports.

An introduction to the greenhouse effect

The present climatic conditions on earth are governed to a large extent by the composition of the atmosphere. Man is modifying the composition of the atmosphere at an unprecedented rate. The thermal balance of the earth is being changed so that warming — and possibly associated climatic changes — will follow depending on the size of the modifications. Increasing attention has been focused in recent years on the role of the so-called 'greenhouse gases' in this warming process. The most common 'greenhouse gas' — carbon dioxide — is released during the production or use of energy, in particular by burning fossil fuels.

Fossil fuel combustion, biomass burning and many other human activities have caused the atmospheric concentration of carbon dioxide to increase by about 25 % since 1860. As CO_2 is responsible for slightly more than 50 % of the greenhouse effect, its control must form a leading element in any strategy for limiting or reducing the impact of this effect.

The timing and severity of global warming due to greenhouse gases may have very important consequences for natural ecosystems and human societies. The rate and degree of possible future warming could be affected by the development and application of alternative energy policies and restrictions on the emission of the greenhouse gases. Emissions of combustion-derived CO_2 are linked both to the levels of future global energy demand and to the overall fuel mix. These provide ample justification for considering the development of alternative and more stringent policy options and, more specifically, R&D programmes in the fields of renewable energies and the rational use of energy and the promotion of safe nuclear technology. Moreover, forestry — or, to be more precise, deforestation — in the tropical regions may also be a relevant area for intervention.

The Commission has recently prepared a Communication on the greenhouse issue. This Communication was presented to the Council of Ministers in charge of the Environment on 24 November 1988. At its meeting, the Environment Council welcomed the report and approved its main conclusions and recommendations going on to declare that the Community should devote increasing attention to the risks of potential climatic changes involved in the greenhouse issue. This article, which concentrates mainly on energy-related CO_2[1] emissions, is in part a summary of the Communication and its recommendations.

Introduction

Global levels of CO_2 in the atmosphere have been rising since about 1860 and have now reached 345 ppm. Two-thirds of the increase has been caused by the combustion of fossil fuels and one-third is the result of deforestation and intensive agricultural activities.

Based on the results of global climatic models, there is a growing consensus of opinion within the scientific community that increasing CO_2 levels and those of other greenhouse gases are accompanied by warming of climates — the greenhouse effect. A doubling of the pre-industrial revolution gases concentration could result in a temperature increase of between 1.5 and 4.5ºC. This is expected to happen before the year 2050. If we are to limit the potential dramatic impact on our environment, we should follow a path which uses the carbon atom in a rational and prudent manner.

What is the greenhouse effect?

Incoming radiation from the sun (mainly as visible radiation but with some ultraviolet) heats the earth's surface. This heating is balanced by the emission of long-wave thermal radiation. A number of gases such as carbon dioxide, methane, water vapour, nitrous oxide, ozone and chlorofluorocarbons (CFCs) are transparent to incoming shortwave radiation but are relatively opaque to out-going longwave and return part of it back to the surface. This induces a rise in the surface and tropospheric temperatures and cooling of upper levels of the atmosphere. This is the so-called 'greenhouse effect'. It should be noted that without this effect, life on earth, as we know it today, would not be possible as the surface of the planet would be around 30-35ºC colder than it is now. However, significant rise in the atmospheric concentrations of the greenhouse gases would result in a change of the global thermal balance of the earth and climatic changes.

Greenhouse gases

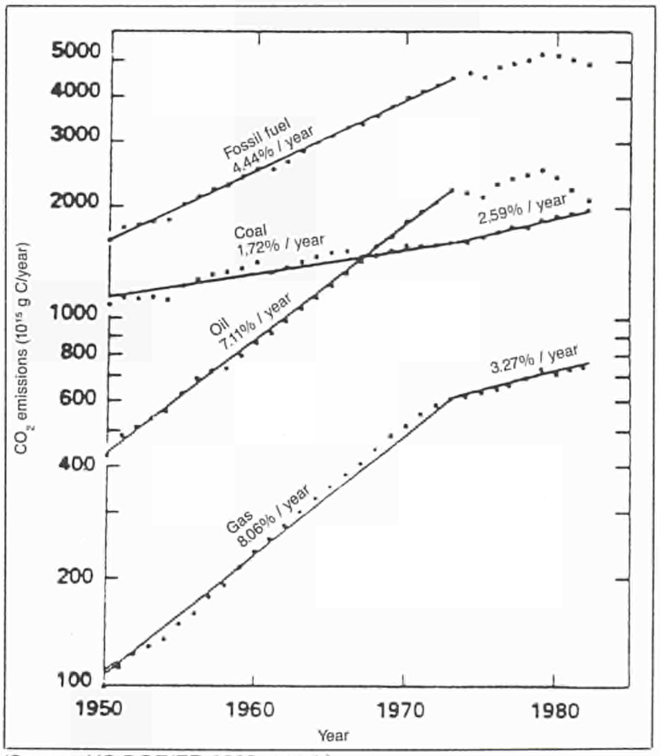
Fossil fuel combustion is the principal (but not the only) cause of increasing atmospheric CO_2.

Carbon dioxide is presently responsible for slightly more than 50% of the greenhouse effect. Another 25% of this effect is due to CFCs used in a variety of applications (such as aerosols, spray cans, air conditioning etc.). The rest is attributable to methane (for 15%), nitrous oxide and tropospheric ozone (for 5%). In the future, these other greenhouse gases are likely to contribute more than half of the possible total commitment to global warming. Most of anthropogenic CO_2 emissions are due to fossil fuel burning (around 5 gigatonnes of carbon per year). Moreover a significant contribution comes from the burning of wood and the decomposition of biomass related to deforestation. Measurements of atmospheric CO_2 concentrations have shown an increase from 315 to 346 ppm between 1958 and 1985. In 1860 they have been estimated as being about 275-285 ppm.

CO_2 world yearly emissions from burning of fossil fuels have increased in the 25 years since 1960, from around 2.5 gigatonnes of carbon to more than 5 gigatonnes in 1985 (Figure 1). Coal and oil give by now an almost equal contribution to CO_2 emission with slightly more than 2 gigatonnes of carbon each, followed by gas with less than one gigatonnes of carbon per year (Table 1).

Figure 1

The trends of CO_2 world emission from different fossil fuels for the period 1950-82



(*Source:* US DOE/ER-0239 report.)

Table 1

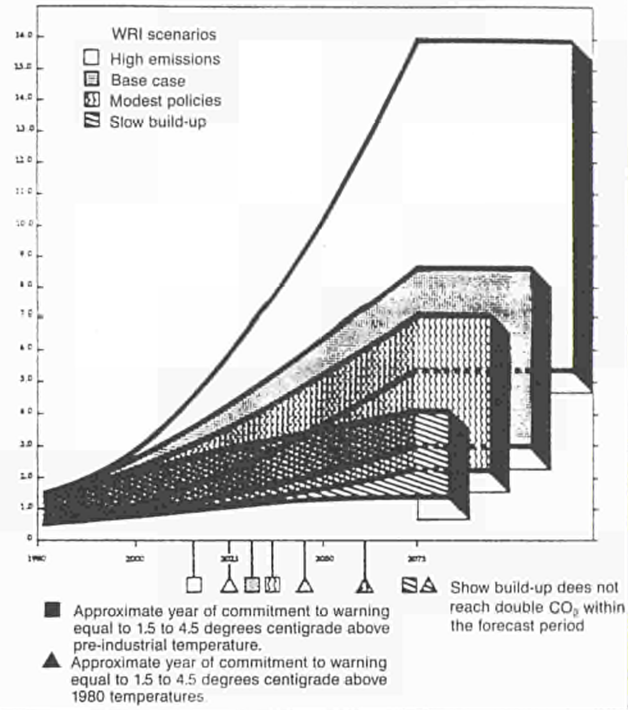
Emission data for 1985 showing contributions from various fossil fuels

Fuel	1985 CO_2 emissions in million tonnes carbon/y
Gas	807
Oil	2 189
Coal	2 181
Gas flaring	52
Total	5 229

Source: I. Mintzer, WRI, 1988.

Greenhouse warming

Figure 2 - Warming commitment in the World Resources Institute scenarios.



Source: Mintzer I. M. (1987); 'A matter of degrees', WRI, Washington DC, USA.

1 *Base case scenario*
- (i) No policy to slow carbon dioxide emissions in the energy industry and to limit tropical deforestation or to encourage reforestation.
- (ii) Minimal stimulus to improve end-use efficiency and for development of solar energy systems.
- (iii) Modest stimulus for synfuels development.
- (iv) Minimal environmental costs included in price of energy.

High emission scenario
- (i) Accelerated growth in energy use is encouraged with no stimulus to improve end-use efficiency and no policies to slow carbon dioxide emissions.
- (ii) Modest stimulus for increased use of coal, strong stimulus for synfuels development but no stimulus for development of solar energy systems.
- (iii) Rapid deforestation.
- (iv) Taken environmental costs included in price of energy.

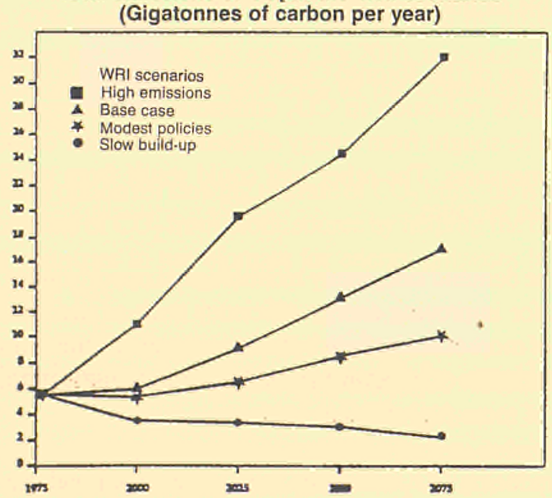
Modest policies scenario
- (i) Strong stimulus to improved end-use efficiency.
- (ii) Modest stimulus for solar energy.
- (iii) Substantial efforts at tropical reforestation and ecosystem protection.
- (iv) Substantial environmental costs imposed on energy prices to discourage solid fuel use and encourage fuel-switching.

Slow build-up scenario
- (i) Strong emphasis placed on improving energy efficiency.
- (ii) Rapid introduction of solar energy encouraged.
- (iii) Major global commitment to reforestation and ecosystem protection.
- (iv) High environmental costs imposed on energy prices to discourage solid fuel use (Mintzer I.M. (1987), 'A matter of degrees', WRI, Washington DC, USA.

The present observed global warming is close to 0.4°C relative to 'climatology' between 1956 and 1980. It is not certain whether this is an early manifestation of a greenhouse effect or a natural climatic fluctuation. Also significant uncertainties exist about the degree of future warming and its timing. Very sophisticated and complex computer models are needed to project future global warming due to emissions of greenhouse gases. These require estimates of the annual amount of energy used, the mix of fuels consumed, and the extent of activities that effect the sources and sinks of all other relevant gases.

The World Resources Institute has produced tentative estimates of possible average warming commitment with reference to four scenarios. These encompassing hypotheses about future developments vary from 'do nothing' coupled with high growth to voluntary emission reduction policies. The scenarios are described in Figure 2 and the warming commitment given for the different scenarios. Figure 3 gives the evolution in the emission rate of CO_2 for the different scenarios. This study foresees only a limited role for nuclearerergg. In none of the scenarios mentioned does the share of nuclear in total primary energy supply exceed 4.5% by 2025. In contrast, the Commission's own energy 2000 study estimated the share of nuclear in the world energy supplies at 7.1% by as early as 2000.

Figure 3
Total emissions of CO_2 in the WRI scenarios
(Gigatonnes of carbon per year)



Forecasting future temperatures are difficult because of the large number of parameters involved but also because of the scientific uncertainties related to the warming due to greenhouse gases. Some scientists tend to agree with the results given by 'global general circulation models' used to simulate the effect of the greenhouse effect on climate. These suggest that: 'the more probable total warming will be of 1.5 to 4.5° C for a doubling of CO_2 concentrations'. A conclusion of the symposium on 'CO_2 and other greenhouse gases: climatic and associated impacts' organized by the Commission in 1986 was that if current trends in greenhouse gas build-up continue, the warming of 1.5° C to 4.5° C will be reached in about 50 years.

Consequences of greenhouse warming

Potential effects of greenhouse warming are: a global-mean precipitation increase (some individual regions might decrease in rainfall), polar winter surface warming, summer continental dryness and warming, high-latitude precipitation increase.

The indirect impacts of such climatic modifications might be summarized as follows:

(i) a sea level rise (from 30 cm to 1.5 m for a warming in the range 1.5 to 4.5° C);

(ii) reduction of sea ice;

(iii) reduction of water resources (especially summer dryness in mid-latitudes);

(iv) modifications in agricultural and forestry productivity;

(v) impacts for human health and ecology.

What has been done? The international framework

A scientific consensus on the basic facts of the greenhouse issue was reached at the 'International Conference on the assessment and the role of CO_2 and of other greenhouse gases in climate variations and associated impacts' (Villach Austria, October 1985). In September of the same year, the European Parliament passed a resolution on measures to counteract rising CO_2 concentrations.

Conclusions of the Villach Conference were further developed at the EEC Symposium on 'CO_2 and other greenhouse gases' (Brussels, November 1986) and at the Workshops on 'Developing policies for responding to climatic change' (Villach, September 1987) and on 'Developing policies for responding to climatic change' (Bellagio, November 1987). The greenhouse issue was also considered by the World Commission on Environment and Development — the Brundtland Commission. This Commission published a detailed report which tries to give an overview of the threats to, and possible paths which can be chosen to achieve sustainable development.

The World Conference on 'The changing atmosphere, implications for global security' held in Toronto, 27 to 30 June 1988 was one of the most recent events of particular importance for future development. The statement from the conference contains two recommendations concerning the field of energy that are of prime interest here:

'An initial global goal should be to reduce CO_2 emissions by approximately 20% of 1988 levels by the year 2005...

Apart from efficiency measures, the desired reduction will require: (i) switching to lower CO_2 emitting fuels, (ii) reviewing strategies for the implementation of renewable energy, especially advanced biomass conversion technologies and (iii) revisiting the nuclear power option, which lost credibility due to problems related to nuclear safety, radioactive wastes, and nuclear weapons proliferation. If these problems can be solved, through improved engineering designs and institutional arrangements, nuclear power could have a role to play in lowering CO_2 emissions.'

The last event where the Commission participated was of the first meeting of the 'International panel of climate change' of the Working Group 3 (policy measures) held in Washington (30.1. to 2.2.1989). It was organized by UNEP/WMO. It was decided that the Commission will be involved in different working bodies on adaptation and reduction policies. As far as energy-related CO_2 emissions are concerned, a group on energy and industry has been established. At the Washington meeting, it was decided that long-term net emission profiles to the year 2090 will be developed for three scenarios: a doubling of pre-industrial $C0_2$ equivalent concentrations by 2030, by 2060 and by 2090 and a holding at that level after each of the dates. The group on energy and industry will define technology and policy options to attempt to reduce emissions of CO_2 and other greenhouse gases to a level consistent with, or below these three emission scenarios.

Future meetings which aim to prepare the way for comprehensive global convention of the protection of the atmosphere include:

(i) an international meeting of legal and policy experts on the protection of the atmosphere held in Ottawa on the 20 to 22 February 1989 and organized by the Government of Canada;

(ii) a high-level political conference on climate change organized by the Government of the Netherlands on 7 and 8 September 1989;

(iii) the Second World Climate Conference, Geneva, June 1990;

(iv) the Intergovernmental Conference on sustainable development in 1992.

Energy measures to reduce the emission of CO_2

The three principal approaches to slowing the rate of CO_2 build-up are:

(1) improving the efficiency of energy supply and use;
(2) shifting the fuel mix toward less CO_2-intensive fuels or non-emitting CO_2 sources;
(3) using biomass for energy in a sustainable way.

Elimination of CO_2 at the source could eventually become a new domain of research. No economically or technically feasible technologies are yet available.

The view of the Toronto Conference was that half of the initial 20% reduction in CO_2 emissions (by the year 2005) could be sought from energy efficiency and other conservation measures. The other half could result from modifications in supplies.

On the demand side, many technological opportunities now exist for improving energy efficiency such as the introduction of more efficient light bulbs in commercial buildings, the construction of better-insulated buildings and the manufacture of more fuel-efficient vehicles.

For reducing CO_2 emissions from commercial fuel use, it is important to note that direct combustion of coal releases 26.7 tonnes of carbon per terajoules (1 terajoule equals 10^{12} joules) whereas oil releases 19.7 tonnes of carbon per TJ and natural gas only 13.7 tonnes per TJ. Per unit of energy, oil emits about 70% as much carbon as coal does and natural gas emits only about half as much. CO_2 emissions are zero with respect to nuclear power (see separate article in this issue) and, except in the burning of biomass, for renewable energy sources.

Much more emphasis could be put on funding development of renewable energy technologies — solar heat, windpower, photovoltaics and hydropower that deliver energy without carbon dioxide. Hydropower is already playing a significant role contributing to 20.6% of the world's electricity production. Table 2 gives a good overview of the use of non-CO_2-emitting sources used to produce electricity in the EC, the United States of America and the world.

Table 2

Share of non-CO_2-emitting source in electricity production

Country	I Hydro-geothermal and solar source (%)	II Nuclear power (%)	Total I + II
EC	11.85	34.01	45.86
United States of America	11.62	17.70	29.32
World	20.64	16.19	36.83

While a great deal of attention is directed towards the use of fossil fuels for electricity generation, it should be noted that a large part of our CO_2 comes from burning fossil fuels outside of power stations. Transport is a sector that produce lots of CO_2. In 1985, the contribution of power generation represented 26% of the CO_2 emission in the EEC, while transport contributed 20% of the CO_2 emission, industry 16% and other sources 37%.

An estimate of the evolution of CO_2 emission in the EEC shows an increase of the contribution of power generation in the CO_2 emission in the EEC (nearly 35% by 2010) if no changes are made in this sector. By 2010, transport could be producing between 20 and 25% of the Community's CO_2 emissions.

A third option for slowing the rate of CO_2 build-up is to limit emissions of CO_2 from biotic source by helping the developing countries to use biomass for energy purposes in a sustainable way.

Review of other possible actions

Forestry policies should tend to reverse present deforestation trends by promoting:

(i) appropriate agricultural practices in developing countries to avoid that agricultural land demand cause further deforestation;

(ii) substitutes for wood where it is used massively as fuel;

(iii) increase afforestation efforts notably in subtropical and tropical regions. There is a call for financial Community development policy measures to stop deforestation in the developing countries.

Other preventive actions to decrease emissions of greenhouse gases are to:

(i) minimize CH_4 losses in extraction, transport and use of natural gas and landfills;

(ii) study possible improvements in livestock management, rice cultivation and lagoons management, aiming at reducing CH_2 release;

(iii) improve fertilizing management practices to reduce N_2O release from nitrogen fertilizers use.

In the case of CFCs, the nearly total elimination of CFCs emissions should be feasible by the year 2000 by constraining production and recapturing, recycling and destroying CFCs in existing products.

Apart from all the preventive measures, some long-term planned adaptive measures should be taken concerning sea level rise and impacts on agriculture.

What are the implications for the Commission in the 'greenhouse effect'?

The Community should welcome initiation of discussions on the possibilities of an international agreement for the future protection of the atmosphere . Therefore, the Commission will take the initiative to launch a substantial policy-options study programme to evaluate the feasibility, costs and likely results of possible measures to limit greenhouse gases emissions.

Of specific interest to the energy sector, the Commission will take action to reinforce and expand efforts in the field of energy savings, energy efficiency improvement, development of new energy sources, use of safe nuclear technology, it being noted that the accelerated development and promotion of innovative commercial-scale technologies in these fields should be given high priority.

The Commission has set up a Committee to exchange information on all the aspects of the greenhouse issue called the *Interservice Working Group on the Greenhouse Issue*. The group mainly consists of representatives from the Directorates-General for Environment (DG XI), Energy (DG XVII), Science, Research and Development (DG XII), Agriculture (DG VI) and Development (DG VIII). Their aim is to see to it that the Community plays its proper role in dealing with this complex problem.

Conclusion

Based on the results of global climatic models, scientists agree that a doubling of the equivalent CO_2 atmospheric concentration will bring an increase of the average surface temperature in the range 1.5-4.5°C. Such doubling is likely to happen within the first half of next century. In order to reduce the risks of future global warming alternative energy policy options must be designed to reduce emissions of CO_2 and other trace gases.

The Community and its Member States should be taking into account in their policy decisions relating to energy, environment and research, the problem of potential climate changes linked to the greenhouse effect.

Contribution of nuclear power to the 'greenhouse effect'

Nuclear power provides a technically proven method for large-scale generation of electricity without parallel production of CO_2 and indeed of other polluting emissions such as NO_x and SO_2. This highlights the need to revisit the nuclear power option which lost much popular support due to perceptions of nuclear safety, radioactive wastes and nuclear weapons. If it can be shown that these doubts are unfounded nuclear could have a still greater role to play in lowering CO_2 emissions.

Calculations within the Directorate-General for Energy show that nuclear power is already playing a significant role for reducing CO_2 emissions per unit of generated electricity in the Community. For the period going from 1970 to 1987 in EUR 12, the use of nuclear power reduced by an important percentage the total potential emissions of CO_2 during electricity generation. Figures 1 and 2 illustrate the evolution of the quantity of CO_2 emitted by producing electricity in EUR 12 and in the USA and to compare it to the amount of CO_2 that we have saved by using nuclear in power plants. This was done for three different hypotheses: the case where nuclear would have been replaced by coal, by oil or by natural gas. The quantity of CO_2 that would have been emitted without nuclear power was calculated by using the coefficients of emissions for the different fuels:

(i) 26.7 tonnes of carbon emitted per terajoule of coal;[1]
(ii) 19.68 tonnes of carbon emitted per terajoule of oil;[2]
(iii) 13.68 tonnes of carbon emitted per terajoule of natural gas[2] (1 TJ = 10^{12} joules).

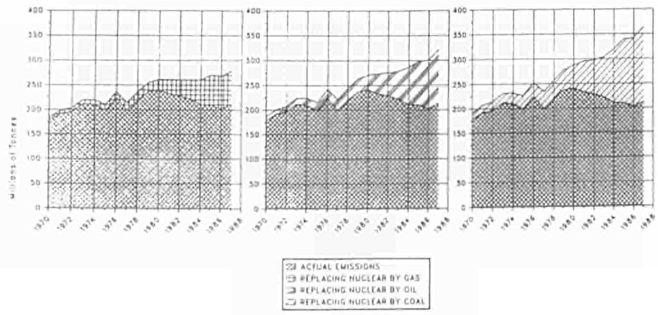
For the period from 1970 to 1987, if we would have used coal in EUR 12 instead of nuclear power, the amount of CO_2 emitted would have been 27% higher (1 050 million tonnes of carbon), using oil, it would have been 18.5% higher (713 million tonnes of carbon) and 12.5% more (476 million tonnes of carbon) using natural gas. It is of particular interest to look at the numbers for the year 1987 where the use of nuclear instead of coal permitted us to save the emission of 151 million tonnes of carbon (Fig. 1). If nuclear had been replacing oil in 1987 the saving would have been 109 million tonnes of carbon and 66.5 if it had been replacing natural gas. For the same year in the United States, the amount of carbon emission saved by nuclear was respectively 128, 91 and 64 million tonnes of carbon (Fig. 2).

In 1987, the amount of CO_2 emitted by burning fossil fuel to generate electricity in EUR 12 was only 16% higher than in 1970 and almost the same as that in 1973. For the United States, the growth of emission was of 38% from the year 1970 to 1987. This can partly be explained by the faster growing rate of electricity production in the United States than in EUR 12 but also because of the greater share of fossil fuels in the United States (Fig. 3). To insure the growth of the electricity production in the USA more coal was used in addition to an increasing share of nuclear power. However, in EUR 12 the use of coal was not much increased and nuclear power was responsible for nearly all the increase of the electricity production from 1973 to 1987.

Nuclear is already contributing to 16% of the world electricity production and represents 5% of the world's energy consumption.

FIG. 1 - EMISSION OF CARBON DURING ELECTRICITY PRODUCTION IN THE E.E.C.

(EUROSTAT, OECD & IAEA Data)



1 World Resources Institute — *Energy policy and global climate change*, National Academy of Sciences, Washington, 5 January 1988.

2 These numbers come from an average from different sources:
(i) US-DOE, 'A glossary on carbon dioxide', March 1988; Using figures from Marland G. and R.M. Rotty, 'Carbon dioxide emissions from fossil fuels: A procedure for estimations and results for 1950-81' (1983).
(ii) Richard Bereford, British Gas Corporation (private communication). Derived from figures in Spears, 'Technical data on fuels', HMSO
(iii) Keepin et al in Scope 29; cited in Irene Smith, 'CO_2 and climatic change', IEA Coal Research, May 1988.
(iv) Edmonds, J. and J. Reilly, 'Global energy and CO_2 to the year 2050', *Energy journal*, Vol. 4 No 3 pp. 21-47; cited in Mintzer, 'A matter of degrees', WRI 1987.

FIG. 2 -EMISSION OF CARBON DURING ELECTRICITY PRODUCTION IN THE U.S.A.

(EUROSTAT, OECD & IAEA Data)

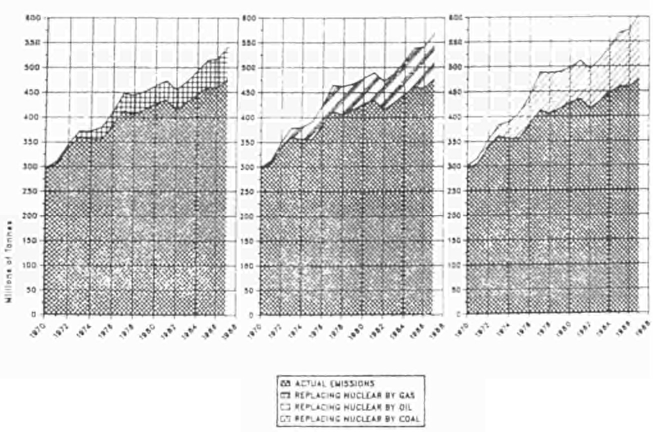
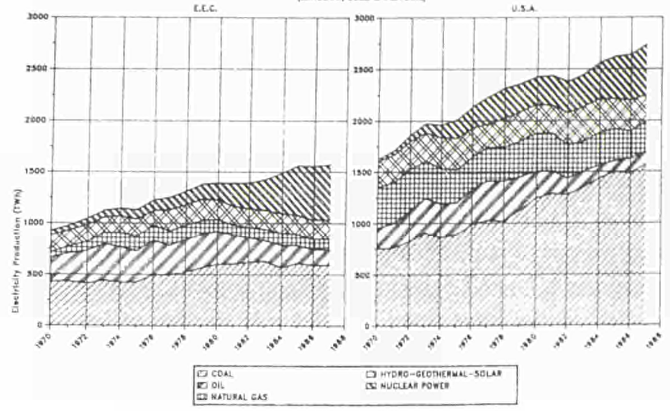


FIG. 3 - STRUCTURE OF ELECTRICITY PRODUCTION

(EUROSTAT, OECD & IAEA Data)



Hydropower — a new perspective?

A new look is being taken at hydropower as a possible source of energy which is indigenous, reliable, often economic, and does not add to the greenhouse effect. This article describes some of the Commission's activities to promote hydroelectric energy.

Introduction

Larger hydroelectric schemes, where the site is favourable, are easily economic and indeed sometimes offer one of the cheapest sources of electricity. Table 1 shows that about 12% of the Community's net electricity production is from hydro, with significant quantities produced in Portugal, Spain, Italy and France. Small hydro, however, is generally less economic and many plants fell into disuse during the era of cheap oil in the 1960s and early 1970s, and as electricity grids were extended.

Table 1
Hydroelectricity as a proportion of total net electricity production — 1987

Member State	Hydro (TWh)	Total (TWh)	% Hydro	(% hydro in 1985)
Belgium	1	60	12	(2)
Denmark	—	28	—	(—)
FR of Germany	20	393	5	(4)
Greece	3	28	11	(12)
Spain	28	127	22	(27)
France	72	360	20	(19)
Ireland	1	12	8	(9)
Italy	42	191	22	(25)
Luxembourg	—	—	—	(—)
Netherlands	—	66	—	(5)
Portugal	9	19	47	(58)
United Kingdom	6	282	2	(3)
Total EUR 12	183	1 566	12	(12)

With the oil shocks of 1973 and 1979, however, attention turned to the various energy alternatives, including the renewable energies. Small hydro, with its long lifetimes, low operating costs and no waste emissions, has the advantages typical of the renewable energies, whilst the typical disadvantages, namely intermittant energy production and low energy density, tend to be less marked. Indeed hydro energy is sometimes associated with a form of energy (i.e. water) storage. For these reasons and because of its potential for technological improvements, small hydro (less than 3 000 kW) has been incorporated in the European Community's energy demonstration programme in each of the 'calls for proposals' from and including 1984.

The Community's energy demonstration programme

The idea of this programme is to encourage the demonstration of innovatory techniques, or new applications of an existing technology, to improve the production, saving or rational use of energy. Various fields are covered, as shown in Table 2, which also shows the numbers of projects submitted in response to the 'calls for proposals' the number of proposals selected and the Community support awarded. An analysis for the alternative energy sector is given in Table 3.

Table 2
Energy demonstration projects, 1978-88

Sector	Projects		Community Support (million ECU)
	Submitted	Selected	
Alternative energy sources	2 440	851	266
Energy saving	2 252	590	249
New methods of using heat, electricity and solid fuels to substitute hydrocarbons	356	137	138
Liquefaction and gasification of solid fuels	180	52	189
Total	5 228	1 630	842

Table 3
Energy demonstration projects. 1978-88 — Alternative energy sector

Energy form	Projects selected	Community support (million ECU)	Average support per project (thousand ECU)
Small hydro	111	25	225
Biomass and energy from waste	191	87	455
Geothermal	130	62	477
Solar energy	280	52	186
Wind energy	139	40	288
Total	851	266	313

In selecting projects for Community support, which usually amounts to 40% of the eligible costs and is no longer repayable, various requirements are sought. The most important of these include, (the appropriate call document and questionnaire should be consulted for the exact conditions):

(i) the need for a significant innovative element;
(ii) the need for preliminary R&D to have been completed;
(iii) the proposal should be for a full size installation, (on Community territory), with a normal operating lifetime;
(iv) the innovation should be potentially economic, if technically successful;
(v) the innovation should be replicable.

This last requirement is most important; the financial support awarded by the Community is to help overcome the risk associated with the demonstration of a new technique for the first time, so that others can subsequently adopt the innovation if it is successful, and not to subsidize an uneconomic proposition. Indeed so important is this replication role that the association in the project of the innovatory equipment producer is usually required, unless acceptable alternative methods of stimulating replication are proposed.

The small hydro sector

An analysis of proposals submitted and selected under the small hydro sector is given in Table 4. It is clear that the figures partly reflect the variations in natural circumstances between Member States, and using Table 1 as a rough indication of the importance of the hydro sector, the activity of France, Italy and more recently Spain (which along with Portugal became a Member of the Community at the beginning of 1986) is not surprising, although the Federal Republic of Germany, Ireland, the UK and Greece have also been relatively active.

Table 4
Energy demonstration programme
Number of small hydro proposals submitted and selected by Member State

Member State	1984		1985		1986		1987		1988		Total	
	Submitted	Selected	Submitted	Selected	Submitted	Selected	Submitted	Selected	Submitted	Selected	Submitted	Selected
Belgium	—	—	3	2	1	1	4	2	1	—	9	5
Denmark	1	1	—	—	—	—	1	—	—	—	2	1
FR of Germany	18	7	4	2	4	2	3	—	3	2	32	13
Greece	5	4	3	1	—	—	3	1	2	1	13	7
Spain					3	2	8	3	8	6	19	11
France	15	6	15	7	15	6	15	7	9	4	69	30
Ireland	6	3	3	2	5	3	3	1	3	2	20	11
Italy	7	3	8	5	6	3	12	3	8	3	41	17
Luxembourg	—	—	—	—	—	—	—	—	—	—	—	—
Netherlands	1	1	—	—	2	1	1	1	—	—	4	3
Portugal					2	2	—	—	1	1	3	3
United Kingdom	4	1	6	3	3	2	3	2	4	2	20	10
Total	57	26	42	22	41	22	53	20	39	21	231	111

As with other sectors, the aim of the programme for small hydro is to demonstrate innovative techniques which will stimulate the development of this energy form, for example, either by reducing costs, by increasing performance or by demonstrating completely new techniques for exploiting water energy. A more detailed analysis of the sort of developments covered by our existing portfolio of projects is given in the separate box.

Low head projects are also well represented in this portfolio:

Head	% of all projects
0 m to 3 m	18
over 3 m to 5 m	25
over 5 m to 20 m	18
over 20 m to 100 m	16
over 100 m to 650 m	23
	100

and installed powers range from 20 kW and less to a few projects close to the 3 000 kW limit. Most projects however are less than 1 000 kW, with a significant number in the 20-500 kW range.

Replication and dissemination

As mentioned earlier, replication of the innovation where successful is the ultimate objective of the programme, and increasing emphasis is being given to the dissemination of results to this end. Dissemination techniques include short descriptive 'flag brochures' for successful projects (so called because their cover page shows the flags of the Community Member States), sectorial booklets, containing descriptive sheets for all projects within a sector, press and magazine articles, and workshops, seminars and conferences.

Mention should also be made of the Commission's computer database system, 'Sesame' which is now open to the public and on which updated project descriptions can be quickly interrogated. Data on national demonstration programmes is also being added to the Sesame database. As something of a latecomer to the programme, however, only relatively few projects in the small hydro field are completed, although work is currently underway on preparing the necessary descriptive information for the various dissemination channels.

The 'contractor' (who proposed and carries out the project) is required to help in this dissemination effort, including the preparation of a publishable final report and participation in workshops, conferences and other such activities. The contractor remains, however, owner of any intellectual property derived from the project, although he may naturally wish to take appropriate measures to protect the intellectual property before information on the project is publically disseminated.

Other Community activities on renewable energies

In addition to its activities to encourage the 'technical' development of the renewable energies, the Commission is also helping to formulate policy measures which will create an environment to allow the renewable energies to play their full role wherever appropriate. The Commission set out an approach to achieve this in its Communication to the Council of 23 January 1986 (COM[88] 12 final)[1] and this approach was adopted, with only minor modifications, by the Member States at the Energy Council of 26 November 1986. A follow-up Communication was then presented (COM[87] 432 final of 29 September 1987)[2] with a list of specific proposals, and these were adopted as a Council Recommendation[3] at the Energy Council of 8 June 1988. (See *Energy in Europe* No 9).

The renewable energies, including hydropower, are also encouraged through the Valoren programme, a programme of financial support for investments, studies and promotional measures for certain indigenous energy forms in disadvantaged areas of the Community. A total of ECU 400 million support has been committed for the five-year programmes (1987-91) in each of the qualifying regions as follows:

	Valoren finance (MECU)	% for small hydro
Portugal	65	24
Greece	50	6
Ireland	25	16
The Mezzogiorno region of Italy	125	29
Certain regions of Spain	105	9
Northern Ireland (UK)	15	—
Corsica and the French Overseas Dept.	15	n/a*
	400	

* n/a = not available.

Another initiative begun by the Commission was the creation of a European Small Hydropower Association (ESHA). Whilst several national hydropower associations already existed, the need for a European association was identified. Under the auspices of the Commission, therefore, representatives of small hydropower from each Member State were invited to Brussels to set up the Association, which was officially established at the end of 1988. The aims of the Association are to protect and promote the interests of small hydro in general and in representations to governments, the European Community, and other official bodies; to exchange information and experiences between its members; and to inform the public at large of the advantages of hydroelectric energy. To help achieve these objectives the Association will circulate a regular Newsletter to its members, and organize conferences, seminars and other events. The Commission also intends to use ESHA to help disseminate the results of the small hydro demonstration programme described above.

The headquarters of ESHA are located in the IDAE (the Spanish Institute for the Diversification and Saving of Energy) offices in Madrid. This Institute, which has given considerable assistance to the birth of ESHA, is also organizing, in conjunction with ESHA and the Commission, a conference on small hydro, to be held in Madrid on 22 to 25 May 1989. Further details on the conference and on ESHA membership can be obtained from:

The Secretary, The European Small Hydropower Association, Instituto para la Diversificacion y Ahorro de la Energia (IDAE), Paseo de la Castellana 95, 28046, Madrid, Spain.

Objectives of the programme

To reduce capital costs:

(i) new materials (e.g. plastics for pipelines, turbine parts and other components);

(ii) other civil work cost reductions (e.g. 'caisson' installation methods and other modular prefabricated units);

(iii) inflatable rubber weirs;

(iv) standardization, simplification or modulization of turbines, possibly for large-scale production. Use of a pump as a turbine.

To reduce operating costs or to increase performance:

(i) improving efficiencies and efficiency ranges:

(ii) new mechanical or electrical regulation systems;

(iii) automatic (and sometimes remote) control with computer optimization systems for the use of the water (sometimes with irrigation needs), electricity tariffs etc. sometimes with multiple turbines in parallel or series;

1 'A Community orientation to develop new and renewable energy sources'.

2 Proposal for a Council Recommendation to the Member States on developing the exploitation of renewable energy sources in the Community.

3 Council Recommendation on developing the exploitation of renewable energy sources in the Community. (OJ L 160 28.6.1988 p. 46).

(iv) multiple schemes to achieve administrative and purchasing economies of scale.

Completely innovative systems:

(i) using river flow (e.g. propeller and various paddle wheel systems);

(ii) low head systems (e.g. projects incorporating the Wells air turbine).

The evolution of the role of energy storage in large-scale interconnected power systems

Electricity demand varies very much from one hour to the next and from one season to another. The differences between the 'peaks and valleys' of the demand curves can be very great. The electricity utilities must meet all the different levels of demand and, at the same time, follow these curves as closely as possible in order to avoid unneccessary use of resources. This can be very difficult, especially as the 'spare' electricity that could be produced during the 'off-peak' periods is not easily stored. This article prepared for Energy in Europe *by Professor Arnaldo Angelini describes possibly the most successful ways of accumulating or storing electricity at an acceptable cost — pumped storage. Professor Angelini is the Honorary President of the Italian electric utility ENEL and a member of the Euratom Scientific and Technical Committee since its creation in 1958.*

Introduction

The essential feature that makes electricity a 'noble' form of energy is that it can be obtained from all the primary sources and then can be broadly distributed and converted into every form needed to be used for a wide variety of applications, cost-effectively and satisfactorily in environmental terms. Moreover, the electricity supply is characterized by the fact that it is taken up by the users as and when needed. This creates a demand that varies throughout the course of the day, with a sharp slump during the night, from day to day and from one season to another.

Electricity can be accumulated or stored in a potential form — after being converted into mechanical energy — and since this would not generally be possible at an acceptable cost to the user, it is the supplier which must constantly have available the variable power needed to meet the user's demands — naturally within the contracted agreed ceilings!

Each domestic, industrial or service (in the broad sense) user has his own load curve. The differences of use between the different sectors creates considerable differences between these curves. The wider the variety of users served, the more marked is the 'offsetting' between different load curves, with the result that the variability of the resultant combined load curve is less marked.

Offsetting the discrepancy between power demand and availability in interconnected systems

The interconnection of networks has been increasing. This occurred first at municipal and provincial level, then at regional and interregional level and finally at national and European level.

Interconnection is the infrastructure which links the production power stations to the storage plants and to substations and distribution centres and thence to the distribution networks supplying each individual user.

The larger the network the less coincidental are the demand peaks and troughs of the users load curves.

Regulating flows using reservoirs has grown in importance considerably as energy consumption has risen, and the gap between power availability and demand has widened at various times in the day, week or season. In fact reservoirs have not only made it possible to use the low and sometimes high river flow rates, to the extent of their capacity in relation to the river flow, but they have also made it possible to raise the plant's capacity in terms of production.

The role of generating and pumping power stations

Italy's first experience in this field dates back to the small power station at Clanezzo (1908), followed in 1912 by Viverone.

The link between economic hydroelectric power production using reservoirs and the role of the generating and pumping power station was described in a paper delivered to the first Congress convened in Brussels by Unipede after the Second World War in 1949.[1] The main purpose of this paper was to examine the possibility of setting-off the hydroelectric power generated by stations in the Alps and the Apennines, in terms of the function of reservoirs regulating that output on a monthly and seasonal basis, in order to identify the features that hydroelectric power stations should possess for seasonal and sometimes interannual and peak-time integration.

---

1 Angelini, A.M.: Aménagements hydroélectriques récents pour le service d'intégration, d'accumulation d'énergie et de pointe' — Unipede: 1949 Brussels Congress.

The paper described the two hydroelectric schemes mentioned above. Further details were provided in subsequent papers. Even in those early days the paper stressed the need for international exchanges and to emphasize the integration of energy production, accumulation and primary transmission subsystems, pointing out 'the possibilities offered by power stations which possess the salient features just described, for the purpose of international energy exchanges scheduled in relation to the planned European interconnection network, which is a topic of great contemporary relevance'.

Italy has developed energy storage by pumping far more than the European average. At the present time, the power obtainable by the pumping stations in Italy accounts for 10% of the total installed capacity. compared with less than 5% in the European Community as a whole.

Since 1963, ENEL has also been developing the large capacity 380 000 volt transmission network, which has enhanced Italy's interconnection by firmly linking it to the whole European network with the same voltage. Furthermore, the unit capacity of the generating and pumping power stations is equal to or greater than that of the thermoelectric and nuclear plants.

The magnitude of tue storage is not limited to the national grid alone, but also extends to the countries with which Italy is interconnected.

In general terms, the main role of generating and pumping power stations is to enhance the utilization of the thermoelectric — and particularly the nuclear — power stations, which are primarily designed for base-load production, for economic reasons above all. The cost-capital ratio of the nuclear plants is such that it makes necessary the highest possible use of available power. It is by meeting this condition which, to a very large extent, makes nuclear power less costly than all the other thermal sources.

With regard to the European electricity system as a whole, it is easy to see the role that reversible generating and pumping power stations are bound to play eventually. Since the essential condition for building such plants is the availability of mountainous areas, in addition to favourable hydrological conditions, it is interesting to compare the relief map of Europe with the interconnection network. The vital role the network plays for the purpose of integrating the production system and the accumulation systems is evident.

Studies undertaken in the 1960s and early 1970s indicated that the power obtainable from the generating and pumping power stations that could be built in Italy totals 30 000 MW. Allowing for the fact that, in 1987 in Europe, and particularly in the countries belonging to UCPTE,[2] output from the thermoelectric plants reached 186 million kW, and 85 million kW from the nuclear plants, there can be little doubt about the relevance of the possible development of the pumped-storage plan by the end of this century and beyond.

Far more so than Europe, Japan considers the role of the generating and pumping power stations to be so essential that out of a total installed capacity of 164 million kW, the generating and pumping power stations already account for 15 million kW, or 9% of the total capacity.

In recent years some of the hydroelectric plants built over half a century ago (at a time when some of them were state-of-the-art!) have been almost completely renovated. The occasion has been used to adapt them, where possible, not only to meet the new regulation capacity but also storage requirements, particularly on a daily and weekly basis. At the same time, completely new high-capacity reversible stations have been built, such as the one on Lake Delio (generating 970 MW and pumping 720 MW), and the Alto Gesso plant (generating and pumping 1 200 MW).

This renewal programme has resulted in increased output and a very substantial increased available capacity and storage potential. The following are examples of a few of the main features of the four widely differing renovated hydroelectric plants. They show *inter alia* the variety of different situations that may arise.

(a) *The Piave-Santa Croce system* has the following features:

(i) Upstream of the Fadalto and Nove plants, the river Piave — whose flow rate fluctuates widely throughout the year — is regulated seasonally by a considerable accumulation capacity.

(ii) The reservoirs of Lago Santa Croce and Lago Morto have been operating for a long time to regulate the production of the two power stations of Fadalto and Nove, built between 1922 and 1926, with an aggregate capacity of 105 MW.

(iii) Restructuring has made it possible to raise the generating capacity from 105 to 275 MW and the annual average production from 620 to 780 million kWh, including 60 million kWh from pumping. At the Fadalto power station, two generating and pum-

2 UCPTE — Union internationale pour la coordination de la production et le transport de l'électricité.

ping units have been installed, each with a generating capacity of 105 MW and a pumping capacity of 75 MW. At the Nove power station, a 65 MW generation unit has been installed.

(iv) Regulation by two new pumping units at Fadalto forms part of a system with an average annual production capacity of 789 million kWh.

(b) *The San Fiorano plant* is another major example of a restructured plant using the runoff from Lago d'Arno, requiring a major variation to the original design: the two heads used at the Isola and Cedegolo power stations, which were built at the turn of the century, have been replaced by one single 1 410 metre head with an underground power station at *San Fiorano.*

The generation power of the whole system has risen from 68 MW to 568 MW using 4 x 142 MW units. Two of these units are reversible and are equipped with pumps each having a capacity of 114 MW.

The plant has an average annual natural production capacity of 350 million kWh which can mostly be concentrated in the winter period, and an average annual pumping production of 250 million kWh, which puts energy to its best use on a daily and weekly basis. It also provides a major reserve function, since the energy that can be accumulated in Lago d'Arno and the other seasonal regulation reservoirs upstream (at Baitone, Salarno and other minor stations) totals 230 million kWh.

(c) *The Brasimone-Suviana plant*. This station offers a major novel feature, in that the pumping unit is inserted between the two existing reservoirs, which are very close to each other: Brasimone and Suviana, both of which are in the Apennines, feeding two small existing power stations, one formerly belonging to an electricity company and the other to the State Railways (before the nationalization of the electric power industry in Italy).

This is a particularly important plant for the following reasons:

(i) the two reservoirs are used not only to regulate the natural incoming runoffs, but also for the new pumping function, with evident substantial economic benefits;

(ii) it uses generating and pumping binary units whose head (387 m) and respective generating capacity (150 000 kW) are state-of-the-art features.

(d) *The renewal of the Sila power station system*. The renovation of this station will not substantially raise the storage capacity, but it is particularly interesting because in addition to generating hydroelectric power, the new scheme will also provide irrigation of some 25 000 hectares in an area in great need of water for agricultural purposes.

In brief, the hydro-resource is better utilized and power production has risen by over 150 million kWh a year. The power stations have been designed to the latest standards and are therefore more efficient, with the possibility of pumping in order to increase the production regulation capacity.

It would be interesting to draw attention to the progress made in the field of the machinery used, and particularly the extension of the field of applications of the reversible binary turbine-pumps in place of the turbine / alternator-motor/ pump ternary units and, particularly, in the case of high heads, the success of multistage machines. However, this lies outside the scope of this article.

The pumped-storage plant programme's contribution to environmental conservation

This major aspect of pumped storage has not hitherto been given the attention it deserves.

Generating and pumping stations raise the 'utilization' of the thermoelectric and nuclear power stations in the sense that with the same capacity, they can increase production considerably. This offers obvious advantages in terms of operation and, above all, in terms of energy costs, because the fixed overhead costs — which are very high in the case of nuclear plants — are diluted because of a greater number of kWh produced annually. For this reason, the pumping and generating plants reduce the overall power demand on traditional thermoelectric and nuclear power plants. This reduction is commensurate to the contribution of the system's generating and pumping stations taken as a whole. The advantage will therefore be that a smaller number of sites will be used for thermoelectric and nuclear plants.

Moreover, when the pumping plants are mainly 'fed' by nuclear-generated power — which is totally free from air pollutants — the atmospheric pollution caused by the plants burning fossil fuels will fall.

The environmental considerations resulting from the construction and operation of pumping stations are:

(i) Those stations being renovated, as described above, do not raise any major problems because they do not require any alterations to the dams, so that the reservoirs are still the same. Moreover, the changes in the utilization scheme of the water have not had any significant effects.

(ii) The new accumulation plants are mostly designed for daily and weekly regulation purposes, and therefore require reservoirs upstream and downstream with fairly small capacity. They are installed in areas (often remote) which do not give rise to environmental problems. Nor are problems raised by the extensive modification of the natural flow of water and by the stations because most of these works are underground.

(iii) There is little alteration to the overall flow rate of the water used. This is because the pumping and generating services alternate. Only a very small area of the catchment basin is generally affected and the downflow-rate fluctuations downstream of the plant are mostly eliminated through the plant's lower reservoir.

Supplementary pumped-storage plants

Supplementary pumped-storage plants are those which are included in the distribution system, rather than in the production and transmission system or those 'terminal' facilities which are installed on the user's own premises.

This form of storage is incremental, because — at least at the present state of technology and for some decades to come — it is highly unlikely that the role of these systems is going to take on dimensions comparable to those of the large pumping stations incorporated into the primary system.

Nevertheless, the study of alternative solutions for energy storage is becoming increasingly relevant and nearly everywhere there are intense research programmes that must be pursued, because the accumulation possibilities using reversible water pumped-storage stations, however large, are limited by the topographical and hydrological situation of the area covered by the European interconnection system. The upper limit of the system could be reached in the first decades of 2000.

Mini reversible power station

Hydroelectric mini-power stations are those whose output is neither substantial nor negligible. They form part of the primary distribution network, or more often of the secondary distribution network.

Hitherto, little attention has been paid to the possibility of associating energy accumulation to production, when the mini-power stations in question are regulated by small reservoirs. In this case, if it were possible to build a small reservoir at the outflow, one could examine the possibility of ascertaining whether the plant could become reversible by installing a turbine-pump in place of a simple turbine.

The availability of conditions suitable for 'mini-reversible power stations' will probably considerably limit the number of stations that could be used for this purpose. However, some possibilities do exist. If the technical feasibility can be shown then economic viability studies will need to be carried out.

Bibliography

'Aménagements hydroélectriques récents pour le service d'intégration, d'accumulation d'énergie et de pointe'; Unipede Congress; Brussels, September 1949.

Energy regulation in large power systems by pumping stations The Institute of Electrical and Electronics Engineers, Inc. 1970 winter meeting.

Evolution and development prospects of pumped-storage plants in Italy; 8th World Energy Conference; Bucharest, June 1971.

Storage as an important tool to improve energy conservation; 10th World Energy Conference, Istanbul, September 1977.

Evolution of water utilization schemes (United Nations, Economic Commission for Europe, Electrcal Energy Commitee, Symposium on the prospects of hydroelectric schemes under the new energy situation and the related problems, Athens, November 1979.

Transport of radioactive materials within the European Community

From the time of the earliest applications of radioactivity and nuclear energy, it was realized that these new techniques required radioactive substances to be transported safely. It was hence necessary to be capable of ensuring that such transport operations would be safe so that man and his environment would be protected.

Shipments of radioactive materials cover a very wide range of products, which include not only all the materials associated with the nuclear fuel cycle but also artificial radioelements.

The latter category accounts for by far the largest proportion (over 90%) of shipments, and includes radioisotopes for medical or research purposes and the transport of gammagraphy equipment containing radioactive sources.

Nuclear fuel cycle materials also cover a very wide range from ores to plutonium and enriched uranium, and including uranium concentrate, UF_6, new and spent fuel and waste.

The number of radioactive packages transported each year in the Member States of the Community is put at over 1.5 million.

A report on the transport of radioactive materials in the European Community has just been prepared by the Special Permanent Working Party for the transport of radioactive substances. This Working Party was set up by the Commission in 1982 in response to a request by the European Parliament. This is the Group's second report.

This article is based on the first part of the report which covers the extent of radioactive material transport, radiation protection and hazards associated with shipments and the need for specific regulations. Details of the regulations and their application will be described in a future issue of Energy in Europe.

Beginnings and growth of the transport of radioactive materials

The transport of radioactive substances is by no means of recent origin.

Even before radioactivity was discovered, uranium ore was already being shipped. Uranium was used from the early 19th century in the ceramics industry for the production of enamels and porcelain.

However, shipments of substances emitting ionizing radiation really began to increase after the discovery of artificial radioactivity and nuclear fission; the discovery of artificial radioactivity led to the use of radioelements in scientific research, then in medicine and finally in industry. Since radioelements are used in many places at some distance from the production centres, shipments entailing all necessary safety measures had to be made via public highways, often under great time pressure owing to the short half-lives of certain elements used in medical diagnosis in particular.

The discovery of nuclear fission led to the setting-up of experimental 'atomic piles' and then to the construction of nuclear power reactors which necessitated the development of a fuel-cycle industry encompassing all the stages in the life of the fuel from uranium ore up to the reprocessing of irradiated fuel and the storage of waste and requiring shipments of radioactive materials between the stages of that cycle.

Extent of transport

The number of shipments increased very rapidly from the late 1940s onwards and, by the end of the 1960s, the packages shipped in the world exceeded a million. In 1980, 1.4 million packages of radioactive materials were shipped within the Community.

A breakdown of this figure by country is as follows: during 1980, some 400 000 packages were transported in the Federal Republic of Germany, 500 000 in France, 250 000 in Italy,

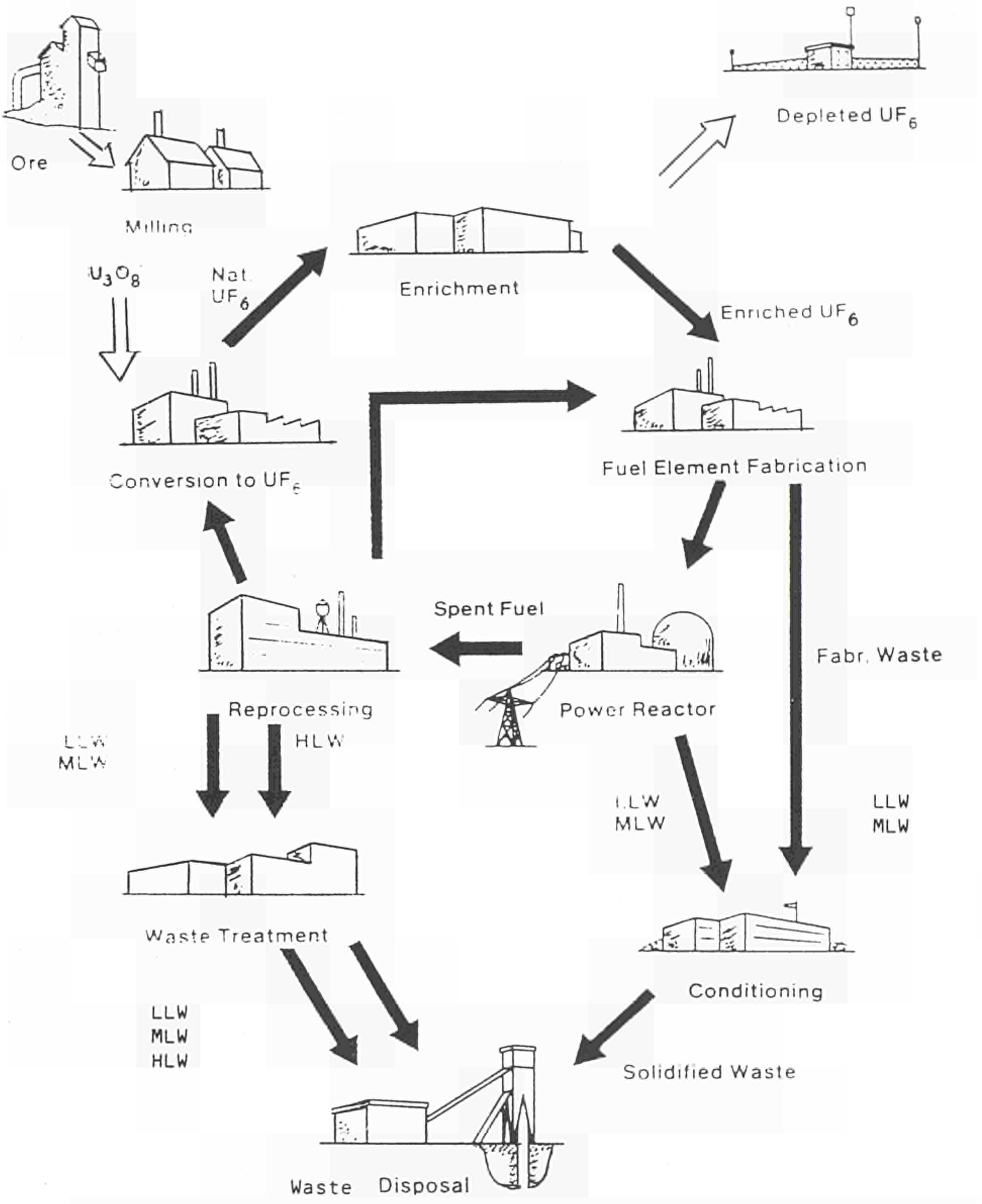


Figure 1 : Stages in the uranium fuel cycle and the associated transport operations.

Legend : LLW : Low - level waste
MLW : Medium - level waste
HLW : High - level waste.

55 000 in Belgium, 25 000 in Denmark and 200 000 in the United Kingdom.

Complete statistics are not available at present, but reliable estimates exist which indicate that millions of radioactive packages are transported all over the world each year.

The International Atomic Energy Agency (IAEA) has requested countries to furnish annual summaries of the shipments made within their territories, which should permit more accurate overall estimates.

Breakdown of shipments according to their various uses

The vast majority of packages of radioactive materials transported is made up of shipments of radioisotopes and of gammagraphic equipment used for non-destructive inspection. In the latter case, many journeys are often made by the same item of equipment, and are sometimes calculated as a single shipment. Of the radioisotope shipments, 90% are made up of radioactive pharmaceutical products and isotopes for medical research; the remainder are composed of large sources for radiation therapy and radioisotopes for industrial uses and research. These shipments of medical radioisotopes involve extremely low levels of hazard.

Less than 5% of all the radioactive materials transported comprise nuclear fuel cycle materials, including radioactive waste.

Nuclear fuel cycle

The transport of radioactive materials associated with the nuclear fuel cycle is directly proportional to the scale of nuclear power programmes. In the Community, the total installed nuclear power increased from less than 1 GWe in 1960 to around 100 GWe in 1988 and is expected to reach 110 GWe by 1995.

Figure 1 shows the basic nuclear fuel cycles associated with the production of electricity. Table 1 shows, for each stage of the cycle, the quantities of materials to be transported in the case of a 1 GWe light-water reactor, together with the number of vehicles required. It must be noted that not all shipments have an equal impact on the environment. Shipments of ores are not taken into account, since the processing plants are usually located near the mines.

Irradiated fuel and waste from reprocessing account for most of the volume of the highly radioactive materials which have to be transported. Vitrified high-level waste has not yet been transported in large quantities. Nevertheless, it is considered that its transport would be safer than that of irradiated fuel because it contains virtually no fissile materials or volatile fission products and is immobilized in a compact glass matrix, which is placed in a stainless-steel drum.

Table 1
Annual shipments associated with the various stages of the nuclear fuel cycle for a light-water reactor of 1 GWe

	Quantity[1] (tonnes)	Activity[2] (Bq)	Number of vehicles[3]
Ores	80 000	$2.2.10^{12}$	—
Concentrates	180	$9.2.10^{10}$	9
UF_6, natural	240	$8.5.10^{10}$	20
UF_6, enriched	50	$1.2.10^{11}$	4
Fresh fuel	30	$1.2.10^{11}$	5
Irradiated (spent) fuel	500	$5.6.10^{18}$	6
Plutonium	0.30	$1.2.10^{15}$	3
High-level waste	130	$5.6.10^{18}$	2
Medium- and low-level waste	1 100	$1.1.10^{14}$	25

[1] The weights are the net weights of the materials to be transported, except in the case of spent fuel and high-level wastes, where the weight is that of the package as a whole.
[2] The activity of concentrates, UF_6 and fresh fuel is very low.
[3] Transport by road is assumed except in the case of spent fuel and high-level waste, where shipment is by rail; in this case, the number relates to wagons instead of road vehicles.

Table 2 shows the net installed capacity of UO_2 fuelled thermal reactors in the Community in 1988 and the corresponding capacity planned for the end of 1995. Comparison of Tables 1 and 2 gives an idea of the volume of traffic in the Member States at the various stages of the nuclear fuel cycle.

Table 2 — Net installed capacity (GWe) of UO_2 — fuelled thermal reactors

(Light-water reactors except in the case of the United Kingdom (First generation gas-cooled reactors and fast reactors — in parentheses

Country	1988	1995 (expected)
Belgium	5.5	5.5
Denmark	—	—
FR of Germany	21.4	23.0
Greece	—	—
Spain	7.1 (0.5)	7.1 (0.5)
France	50.7 (2.2, *1.4*)	57.6 (2.2, *1.4*)
Ireland	—	—
Italy	1.10	—
Luxembourg	—	—
Netherlands	0.51	0.51
Portugal	—	—
United Kingdom	12.2[1]	13.2[1]

[1] Includes Magnox, AGRS and (in 1995) Singewell-B.stations.

Transport of radioactive materials and transport of dangerous materials

Although the numbers of shipments of radioactive materials are high, they account for only a very small part, of the order of 1%, of all the 'dangerous goods' shipped within each country and during international transport operations.

The term 'dangerous goods' covers an extremely wide range of products: explosive materials, inflammable substances, toxic substances, corrosive substances, etc. In fact the potential hazards arising from some of these products can exceed those associated with radioactive materials.

It is only natural that radioactive materials should be covered by the regulations governing the transport of dangerous goods and form one of the categories of goods in that context. Certain principles and general rules relating to the transport of dangerous goods are, moreover, as applicable to radioactive substances as they are to goods in the other categories.

Furthermore, certain hazards associated with radioactive materials, such as chemical toxicity, corrosiveness and explosibility, are shared with other dangerous materials; such risks are taken into account in the preparation of the transport rules.

Hazards associated with the transport of radioactive materials

Radioactive materials and certain fissile materials do give rise to quite specific hazards during transport.

(i) The hazards of external irradiation. These result from the exposure of persons to radiation emitted by an inadequately shielded radioactive substance;

(ii) the contamination hazards arising from the transfer of radioactive substances to the environment, which is likely to occur if a certain quantity of dispersible radioactive material escapes from the containment provided by the packaging. This may lead to the internal contamination of members of the public or of the personnel involved in transport operations through inhalation or ingestion;

(iii) in the case of certain fissile materials, there is also the criticality hazard, that is to say the risk of initiating an uncontrolled chain reaction following the accidental concentration of quantities of fissile materials exceeding the critical mass.

The release of the heat caused by radioactivity must also be taken into account where some categories of radioactive materials are concerned.

As in the case of all shipments of dangerous materials, it is in the event of an accident in which the packaging is either destroyed or loses its capacity to contain the radioactive material or attenuate adequately the radiation emitted that the hazards previously referred to are likely to arise. However, very slight risks can exist during the transport of radioactive materials even when no accident occurs, and they have to be taken into account in the transport rules.

In a study of the potential hazards associated with shipments of radioactive materials, it is hence necessary to take into consideration both accident and normal conditions:

Hazards under accident conditions

The hazard is expressed as the product of the probability of an accident multiplied by the consequences of that accident. The consequences of destruction of a packaging vary considerably according to the extent of the destruction, the characteristics of the material being transported, the level of radioactivity contained within the package, the type of radiation emitted by the material and the material's capacity to disperse.

In the case of a non-dispersible solid, for example, which emits only alpha- (α-) radiation, the risk of both contamination and irradiation is very slight. Even in the case of a dispersible solid, the risk of contamination is slight as long as the material is only slightly radiotoxic.

The packaging therefore has to be suited to the material to be shipped.

Above a certain threshold, which is a function of the material's radiotoxicity and dispersibility, the packaging must be capable of containing the material irrespective of the conditions that might be encountered during the transport operations. On the other hand, below that limit, various levels of damage to the packaging can be accepted in the event of an accident; however, the radiation protection rules must be observed under all circumstances.

Hazards under normal transport conditions

Under normal transport conditions the packaging obviously remains intact throughout the transport operation and no radioactive material escapes. This also applies to dangerous materials, but two aspects make the case of radioactive materials somewhat different:

(a) the radiation attenuation mode follows an exponential curve. This means that, in order to reduce residual radiation to a value which is virtually equal to zero, it would be necessary for the packaging to include a very great thickness of absorbent materials. In practice, the regulations lay down limit values for the radiation dose rate emitted by the package. These values are based on an optimization determined in accordance with the ICRP recommendations. For the sake of prudence, it is accepted at present that even very low doses are likely to have a certain effect from a health standpoint and that, in consequence, even though the hazard is extremely slight, it cannot be considered as absolutely non-existent;

(b) slight radioactive contamination of the outer packaging surface is possible. This is the case, for example, with large transport packages of irradiated fuel (commonly called 'transport casks'), which are loaded under water in storage ponds in order to protect the operators from the radiation. On leaving the ponds, the casks are cleaned, but residual contamination may remain. The regulations lay down a limit value for such contamination.

The need for specific regulations

It became evident very early on that there was a need for specific regulations to ensure that radioactive materials would be transported under absolutely satisfactory safety conditions and, in particular, that an adequate radiation protection level would be maintained both for the personnel responsible for the shipment and for the public. Rules already existed for the transport of dangerous goods (explosives, highly toxic products, etc.) the potential hazard of which was comparable to, or even greater than, that of radioactive substances. The radiation protection rules were likewise well known, but it was necessary to adapt them to transport conditions, just as transport conditions had to be adapted to meet radiation protection requirements.

These rules were initially developed for the laboratories where radioactive substances were handled and then for nuclear reactors and the fuel-cycle plants. In all these fixed installations, the environmental conditions are known and the work is carried out only by specialized personnel who have received suitable training. In the case of the transport of radioactive materials, the materials are shipped by various means of transport and by widely varying routes. The use of radioisotopes in medicine would be gravely compromised if it were necessary to restrict the means of transport to be used or the routes to be followed. Furthermore, even on the routes chosen, accidents may be caused by other vehicles.

In 1948 the first national regulations for the transport of radioactive materials ('Radioactive Substances Act' put into effect by the British Government) appeared which contained the basic elements for regulating safe transport.

Since it was set up in 1957, the IAEA has assumed the task of drawing up recommendations at international level to enable national regulations to be harmonized and to facilitate international shipments of radioactive materials. The first international regulations on the transport of radioactive materials were prepared by the IAEA in 1961 with the cooperation of its Member States and the international transport organizations. The document containing these Regulations is entitled 'Regulations for the Safe Transport of Radioactive Materials'; it was revised and updated in 1964, 1967, 1973 and 1985 in order to reflect experience of its applications, new trends in radiation protection and advances achieved in methods and technology. It is continuously updated; the next revision, now in preparation, is scheduled for 1995. (These regulations will be described in more detail in the next issue of *Energy in Europe).*

It should be stressed that it was in connection with the transport of radioactive materials that the first regulations intended to be applied by all countries in the world were prepared; this can be explained by the extent of international transport operations involving radioactive materials.

Third-party liability in the event of damage caused by international shipments

Just as the increasing frequency and the expansion of international shipments gave rise to the establishment of rules common to different countries based on the IAEA Regulations, they also led to conventions defining where responsibility lies in the event of damage during transport.

Although the aim of the regulations is to prevent any accident likely to have consequences from a health standpoint, it was indispensable to establish clearly where responsibility lay during transport, in view of the fact that several carriers often participate in succession in international transport operations. This was done by drawing up international conventions (Paris Convention of 1960, amended in 1964 and 1982, Vienna Convention of 1963 and the Brussels supplementary Convention of 1963).

At a conference held jointly by the IAEA and the Nuclear Energy Agency (NEA) of the OECD on 29 September 1988, a joint Protocol was adopted which establishes a link between the Paris Convention and the Vienna Convention.

It allows the States which accede to it to benefit from the cover provided by both Conventions and, in particular, it resolves the legal conflicts that might result from the application of both Conventions to the same nuclear accident, especially in the case of international shipments of nuclear materials.

This Protocol has already been signed by 18 States, including nine Community Member States (France, Ireland and Luxembourg have not yet signed).

Safety regulations and the physical protection of nuclear materials

Allowance also has to be made for another hazard of an altogether different nature associated with the shipment of certain radioactive materials, namely the risk of malicious acts. This concerns the transport of fissile materials such as plutonium and uranium 235 *and also products which are highly toxic or highly radioactive*. Materials might be stolen with a view to blackmail, e.g. the threat of making a 'home-made' atomic bomb or of contaminating the drinking water supply.

The same risk is also present in the shipment of other dangerous materials in general. However strong a packaging may be, it can always be opened deliberately during transport since it is designed to be opened on arrival. However, in the case of heavy packagings of the type used to transport irradiated fuel, the weight of the components (a lid can weigh several tonnes) acts as its own protection.

Physical protection of nuclear materials is the subject of a very tight international regime already in force. Therefore, the Working Party's report does not address further the risks related specifically to malicious acts and the physical protection of nuclear materials other than pointing out that these are covered by special regulations at national level and the International Convention on the Physical Protection of Nuclear Materials.

Under that Convention, the signatory States undertake to apply certain levels of physical protection during international shipments of nuclear materials. They also undertake not to effect imports or exports if these levels of protection are not observed throughout the corresponding international shipments. The Community is a signatory to the Convention by virtue of its responsibilities for the supply of nuclear fuels, particularly under Article 59 of the Euratom Treaty. (The Community and its Member States will collectively ratify the Convention).

Radiation protection in relation to transport of radioactive materials

Principles

The Council Directives[1] on health protection are based on the following three principles which are in conformity with the recommendations of the International Commission on Radiological Protection (ICRP):

(i) no activity giving rise to exposure to ionizing radiation should be undertaken if the advantages of such activity have not been clearly demonstrated (principle of justification);

(ii) exposure to radiation must be kept to a level as low as reasonably achievable (principle of optimization);

(iii) the exposure of human beings must not exceed the permissible dose limits (principle of limitation of individual exposure).

In the case of radioactive shipments, only the last two principles are applicable, since justification of the shipments is a corollary of justification of the use of radioelements and of nuclear power production, both of which require transport operations. It is only in very special cases that the grounds put forward to justify the shipments may have to be studied (e.g. the combination on a single site or the setting-up on two different sites of certain fuel-cycle plants).

Application of the principles

Principle of optimization

As stated earlier, the gamma radiation emitted by the materials during transport theoretically cannot be reduced to zero.

The regulations provide for a system to limit the dose rates (expressed as mSV/h or mrem/h) at the outer surface of the packages and at a distance of 1m. The setting of these limits results from optimization in accordance with the ICRP Recommendations. Increasing the thickness of the shielding in order to achieve zero or virtually zero dose rates would lead

1 Council Directive 80/836/Euratom of 15 July 1980 amending the Directives laying down the basic safety standards for the health protection of the general public and workers against the dangers of ionizing radiation, OJ L 246, 17.9.1980.

Council Directive 84/467/Euratom of 3 September 1984 amending Directive 80/836/Euratom, OJ L 265, 5.10.1984.

to excessively heavy packagings, especially for radioelements for medical uses, and could even bring about the prohibition of certain modes of transport (for handling reasons), thus effectively prohibiting the use of the radioelements.

The doses likely to result from these values have to be within the limits laid down by the Council Directives on health protection. In fact, they amount to only a small fraction of those limits.

Principle of limitation of individual exposure

The principle of dose limitation requires that as a function of the physical and radioactive characteristics of the substances being shipped, calculations be performed of, on the one hand, the maximum irradiation level to which may be subjected the personnel called upon to intervene in the event of an accident (police, fire brigade, emergency personnel, etc.) and any member of the public who happens to be at the site of the accident and, on the other hand, the maximum quantities of radioactive substance and a given physical state, above which no release of radioactive material from the package is permissible and containments of the material in question must be ensured. That limit value is applicable irrespective of the transport conditions and of the accidents that are likely to occur during the transport operation.

Protection against other hazards

Protection against hazards other than those associated with radioactivity is provided by means similar to those used in the transport of other dangerous goods.

The regulations, moreover, explicitly require that radioactive materials possessing characteristics such as explosibility, inflammability, pyrophoricity, chemical toxicity or corrosiveness must also comply for transport purposes with the provisions applicable to such characteristics which are set out in the other transport regulations.

As regards the hazard associated with heat release, the regulations contain provisions intended to ensure that there is effective dissipation of any heat released by radiation emitted by the materials being shipped. The objective of these provisions is twofold: to ensure packaging integrity and to prevent persons and goods from suffering damage as the result of high temperatures at the accessible surfaces of the packagings.

Experience acquired

The experience acquired over the last 30 years shows that the radiation doses received by workers assigned to the transport of radioactive materials are well below the dose limits laid down in the Council Directive not only for workers but also for members of the public in the vast majority of cases. It is only during handling operations when packages are being loaded on to transport vehicles, when a large number of packages are being transferred by one and the same device, that certain workers may receive annual doses exceeding the limit laid down for members of the public. In such cases, the workers concerned operate within the framework of a radiation protection programme which includes provision of the information and training required by the Directive.

During that 30-year period, millions of packages containing radioactive substances and fissile materials, including fresh or irradiated nuclear fuel and plutonium, were shipped within the Community. Only a very small number of packages were involved in an accident and in only a few cases were part of the contents released into the environment; on none of these occasions did contamination and the resulting radiation reach a significant level.

Since the safety standards for humans are very strict, environmental protection is thus also implicitly taken into account in the Regulations.

An *ad hoc* group was set up by the IAEA to study the application of ICRP recommendations to the transport of radioactive materials and, where necessary, to optimize protection of the public and the environment according to the means of transport and the routes followed. From the conclusions reached by that group, it emerges that there is no technical reason or reason connected with radiation protection to make specific routes mandatory or to prohibit any particular means of transport. However, this does not prevent certain problems of a psychological nature from continuing to arise.

In short, it may hence be concluded that the very wide range of experience acquired over the last 30 years shows that, in the transport of all types of radioactive material, a very high level of safety has been attained and that both the public and the personnel assigned to transport operations are fully protected against the hazards associated with radioactivity.

SER photosystem

Stereo-photogrammetry by helicopter

The last two decades have seen an increase in offshore operations for hydrocarbons exploration and production. This has particularly been the case in the North Sea where more complex structures have been installed further out at sea and in deeper waters, thus in harsher meteorological conditions. This evolution has been accompanied by an increase of the complexity of the structures.

The magnitude of the investments requires greater reliability and safety for the installations and workers. In order to improve the design, to reduce time and costs during construction and installation, it is necessary to know the exact dimensional situation of all the structures and equipment installed offshore.

Early in the 1980s, AGIP SpA has recognized the need to perfect the methods already in use. The Community, considering the great importance of this effort for the security of its hydrocarbons supply, granted support to AGIP for a project aiming at the development of a stereo-photogrammetry system to be used from a helicopter for dimensional checking and 'as-built' surveys of offshore structures. Consequently, the Commission, under the programme of support for Community projects in the oil and gas sector, Regulation 3639/85, has concluded a contract with AGIP to develop this innovative system, (TH. 15.044/85).

The developed technology

The system consists of special stereo-photogrammetric instruments installed and used from a helicopter.

The principle of this method is to photograph the object to be measured with synchronized twin cameras, in order to cancel the effect of movement of the object or the aircraft. The two photographs are then introduced in stereo plotting instruments and duly processed with analogical/analytical procedures in order to check if the filmed object is within the prescribed tolerances.

The system is fitted on a medium-large helicopter which must carry the equipment and two operators needed to perform the measurements. For this reason and also the necessity to reduce the level of vibrations, a turbine driven helicopter of Augusta — AB 412 SP type — has been chosen. This aircraft was developed based on an earlier model to obtain a consistent reduction in vibration by replacing the double-blade rotor with a four-blade one, made of composite material with elastomer hub bearings and a pendulum device for energy absorption.

The mechanical insulation of the photographic equipment from the fuselage and the need to create a supporting structure, which would fix the centre-to-centre axis required by the photogrammetry specifications, demanded a significant effort. The weight and size has to be kept minimal in order not to hamper the behaviour of the aircraft in flight. The design consists of a pipe transversally fitted to the helicopter passing through the passengers' cabin. The two pod-shaped containers for the photographic equipment and the two range finders are fixed at the pipe extremities via spring and cushion devices to lower vibration consequences.

The SER heliborn system also included the monitoring of the photogrammetry and the checking of the stationary position when photographs are taken.

System performance and possible applications

Although the SER photosystem is rather complex, the cost and time savings aspects, the reduction of risks to the operators and the possibility to survey offshore structures, have proved it economically valuable.

The application of the system to check cluster allows gathering of general information on the pipes and their configuration, such as alignment, parallelism, perpendicularity, general bearing plane etc.

The possible use of this method for the measurement of floating structures is the most interesting one. Particularly the immediate survey of damages on ships after collision becomes feasible.

In addition the method may be used for checking offshore jackets after their open-sea launching. Finally, photogrammetric dimensional checking is particularly useful in the 'as-built' surveys of complex industrial plants with extensive piping networks and large equipment, installed either offshore or onshore.

The work carried out by AGIP SpA with Community support has made it possible to achieve significant improvements in measuring techniques offshore. The innovative photogrammetric procedure represents a major progress when compared to conventional techniques. Its use in engineering applications, allowing reduction of costs of safety monitoring, will be an important contribution to the progress of technology.

Further information can be obtained from AGIP SpA, CP 12069, Milan, Italy.

Community news

European Parliament

On 1 March 1989, the President of the Energy Council, **Mr Aranzadi** (Spanish Minister for Industry and Energy), addressed the European Parliament's Committee on Energy Research and Technology. Mr Aranzadi's speech is reproduced below.

'It is a great honour to outline the energy programme to your Committee during Spain's first Presidency. We all know that energy is fundamental to all economic activity in our countries and, hence, to the European Community as a whole.

Today the action taken by the Community on energy has added significance as we lay the foundations of a Community energy policy with the objective of ensuring that energy, as a basic input for all other sectors, smooths the way for sustained economic growth in Europe.

To achieve this, a coordinated package of measures will be needed, all directed towards:

(i) improving the strategic conditions for self-sufficiency, diversification of energy supplies and technological progress;

(ii) increasing energy efficiency and the competitiveness of companies in this industry; and

(iii) making Community citizens' environmental concerns an integral part of energy policy.

The Spanish Presidency's top two energy policy objectives are:

(1) to take the first steps towards building the internal energy market; and

(2) to update and extend the Community's promotion and technological cooperation programmes for the energy sector.

In addition to these two priorities, we plan to promote energy efficiency by approving the proposal for a Decision on improving the efficiency of electricity use, to open talks on the need to amend the Directive on the use of natural gas in power stations and, finally, to review the situation and prospect for the refining industry in the Community.

Now let us look at this programme in closer detail.

1. Completion of the internal energy market

One of the principal conclusions of the Council meeting on energy last November was that energy has a contribution to make to the single Community market. Beyond a doubt, this contribution will take the form of a higher quality of service accompanied by efforts to define the internal energy market concept.

Only by defining the scope of the internal energy market can we cement the individual measures taken into a comprehensive policy, rather than just a succession of disjointed moves which, despite their undoubted value, are simply too piecemeal.

Energy's contribution to the Community-wide internal market will be to create conditions enabling European consumers to benefit from secure, increasingly diversified energy supplies in a better balanced technological situation than today's.

Closer integration of the energy industries in Europe is an essential part of the process of cutting costs and boosting the Member States' economic competitiveness, while supplying the Community's citizens with energy and a higher quality of service at lower cost.

In this connection, the European Parliament, the Council and the Commission must work together to draft general terms of reference laying down the limits of the internal energy market, defining how it relates to other branches of industry and setting the competition, strategic, environmental and regional objectives. Thought must be given to the unique features of each of the branches of the Community energy market, some of which are far more integrated than others.

The oil and gas markets are more integrated than all the other branches. Both are being opened up to increasing competition. Nevertheless progress is also needed on the more general aspects of the internal market and on a coordinated supply policy.

Given the strategic importance of coal to the Community, which produces two thirds of the tonnage which it consumes, one of the key energy policy challenges facing the European Economic Community in the short term is to establish common principles for the coal industry.

Completion of the internal electricity market will be a more complex task because of the unique technical features of electricity generation, transmission and distribution. Formidable barriers, such as siting restrictions and the heavy investment needed, hamper access to the generation side of the industry. The transmission and distribution sides in turn are typical natural monopolies. The need for power to be generated as it is consumed and the security of supply obligations imposed on the electricity industry are two more marked differences from other economic activities.

In addition, the Council meeting on 8 November stressed that other work on the internal market though not specifically on the energy sector could still be of vital importance to it. Two topical examples are the proposals on public procurement and on indirect taxation.

The Commission is preparing a series of reports and proposals on specific fundamental aspects of the internal market. The Council is eagerly awaiting these previews of the work which lies ahead.

Five aspects are particularly noteworthy:

1. First, price transparency, which is a *sine qua non* for an internal energy market creating far greater opportunities for intra-Community energy transfers to harness the existing comparative advantages and obtain cheaper products and services.

   The first stage of the Commission's work concentrated on prices to large gas and electricity consumers. The Council will consider the results at its next meeting on energy.

   The second stage will focus on indepth studies of the tariff conditions applied to intra-Community energy transfers, i.e. to cost transparency.

2. Second, more transparent energy prices and costs will help produce a fairer approach to the 'common carriage' concept which the Commission is now studying in depth. As you all know, since each branch of the energy market has its own unique strategic, technical and economic features, each must be considered in its own right.

   Increased electricity transfers within the Community will bring definite benefits. However, all steps taken in this direction must be designed to improve the national electricity grids yet preserve the security of supply and stability which they offer.

   In this connection, I feel that the idea of an internal market of integrated electricity grids, each retaining their own efficient management set-ups, could well be the right approach.

3. Energy infrastructure policy is the third component in completion of the internal market. Clearly implementation of the Single European Act is bound to increase transfers between Member States. This in turn will call for a policy to promote investment in energy infrastructure. The Council of Ministers regards an extension of the distribution grids to give citizens everywhere in the Community the same quality of service and an extension of the transmission grids to allow transfrontier interconnection as two objectives of fundamental importance to completion of the internal market.

   In this context, full account must be taken not only of the objective of increasing economic and social cohesion but also of the specific situation in each region, particularly the peripheral parts of the Community.

4. Next, the Council has welcomed the Commission's plans to prepare as quickly and thoroughly as possible a consistent programme striking a reasonable balance between energy and the environment.

5. Finally, two other aspects essential to the energy sector are now being discussed: harmonization of indirect taxation and the opening-up of the types of public procurement still closed to competition.

   The Council meetings on energy must generate ideas on both these aspects of completion of the internal market and define the flexible, specific conditions best suited to closer integration of the various branches of the energy industry.

2. Updating and extension of the Community programmes on promotion and technological cooperation in the energy sector

I said that one of the basic objectives under our Presidency would be to update and extend the Community programmes to disseminate innovative energy technologies.

At its next meeting on energy, the Council will evaluate the results of two Community programmes ending later this year, one on demonstration projects, the other on technological development in the oil and gas sector.

At the same time the Commission is expected to submit a new proposal — for the Thermie programme to follow up the two earlier programmes and provide fresh incentives for technological development in Europe.

The new programme must provide an adequate response to the security of supply and economic problems associated with each source and set the scene for further research and development work on cleaner technologies. More specifically, energy efficiency, renewables, clean combustion, and oil and gas prospecting and production are the technologies which must be given priority.

Moreover, the programme must narrow the gaps between different regions and raise technological standards in the Community as a whole and in each Member State.

The Thermie programme is fundamental to completion of the internal market, since a steady transfer of technology is the key to a successful contribution to the single market by the energy industry.

3. Other issues

Under the Spanish Presidency, the Council plans three further measures to coordinate the Member States' energy policies:

A. an analysis of the refining industry;

B. further promotion of energy efficiency by approving the proposal for a Decision on more efficient use of electricity;

C. discussion of the current situation as regards electricity generation from natural gas.

A. Oil market and recent developments and prospects in the refining industry

The Commission's report on the oil market and recent developments and prospects in the refining industry in the Community analyses the worst problems still besetting the Community's refining industry. The changing energy scene, shifts in the quantity and quality of products required and tougher environmental standards all call for rapid conclusion of the work started at the last formal Council meeting on energy.

It would be invaluable if the Council could analyse the problems posed by the persistent overcapacity, the measures needed to improve conditions of supply and the profitability of the industry and ways of striking a balance between the refining industry and the environment.

B. Use of natural gas in power stations

In February 1975, in response to the first energy crisis, the Council adopted Directive 75/404/EEC on the restriction of the use of natural gas in power stations.

Naturally, the situation has changed beyond recognition since this Directive was adopted. It is time for the Council to consider whether there are other reasons for retaining this restrictive policy. Perhaps one of the most important might be the need to limit the amount of oil and gas burnt to generate electricity in order to keep on target for the Community's energy policy objectives for 1995. I am thinking in particular of the objectives concerning nuclear energy's and coal's share of primary energy production and of increasing self-sufficiency and reducing dependence on outside suppliers.

C. More efficient use of electricity

As I mentioned earlier, the energy efficiency objectives are of vital importance for encouraging the best possible use of each branch of the Community energy market.

The proposal for a Council Decision on a Community action programme for improving the efficiency of electricity use is the fruit of an idea endorsed by the Council and first floated by the Commission towards the end of 1987.

I consider this programme an important boost to making more efficient use of electricity and to raising the technical standards for electrical appliances. Also, in the medium term, an effective energy-saving programme will improve the quality of our environment. These then are the general lines along which we must continue and step up our work this year.

As you all know, last December the European Council requested the Council of Ministers urgently to step up its efforts to extend the internal market to all areas of economic activity and stressed that little progress had been made in some fields, including the energy sector. I can assure you that the Spanish Presidency has taken due note of this request and will give priority to progress in this direction.'

ECSC Consultative Committee

On 16 December 1988, the Consultative Committee gave its opinion of the Commission's Communication on the outlook for the solid fuels market in 1989. The Committee took the view that the unfavourable trend in production and deliveries of coal should lead the Commission to take steps to oppose it, since it makes the Community more and more dependent on imported coal. The Commission is asked to favour long-term delivery contracts.

The next session of the Consultative Committee was held in Toulouse on 13 and 14 March with the following agenda:

(i) Commission report on the solid fuels market in 1988 and the outlook for 1989;

(ii) ECSC R&D programme;

(iii) Commission report on the implementation of the Community system of State aids to the coal industry in 1987.

Joule: Research and technological development programme in non-nuclear energy and the rational use of energy

Increasing the long-term security of energy supply and reducing energy imports through the diversification of sources and a more efficient use of energy are the Community's key energy objectives for 1995. The provision of energy is not an end in itself but a factor of economic and social development.

Recent reductions in oil prices have led to considerably reduced R&D funding. Yet there is a need to pursue the research done so far in order not to lose momentum and to ensure that suitable technologies are available when energy supply becomes more critical. Renewable energies do not yet rest on a firm industrial base. They require longer-term R&D efforts and political commitment to carry their development through in the face of short-term fluctuations in energy prices.

On 14 March 1989 the Council adopted a Community research and technological development programme in the fields of non-nuclear energy and the rational use of energy (1989-92).

The programme will be known as Joule: Joint opportunities for unconventional or long-term energy supply, and will ensure the continuity of efforts undertaken since 1975 and guarantee that maximum benefit will be drawn from the results obtained and the progress made so far in energy technology.

As well as providing a scientific and technical support for Community energy objectives, Joule will focus on alleviating the environmental problems related to energy conversion and use. It should contribute towards the industrial competitiveness of the Community by helping to make clean energy cheaper and by developing new energy technologies to compete on the world market.

Joule will also contribute to the establishment of consistent norms and standards of performance and quality for the large internal market of 1992. It is particularly suited to fostering transnational cooperation between Member States, and will enhance the economic and social cohesion of the Community.

The budget for Joule is ECU 122 million, and the programme will be carried out by means of shared-cost contracts to fund projects which will normally be carried out by participants from more than one Member State: industrial companies (including SMEs), research institutions, universities and individuals. For shared-cost contracts the Community participation will be 50% of total expenditure. There will also be coordination projects and training or mobility awards. In the case of universities and higher education institutions, the Communtiy may fund up to 100% of the additional expenditure involved. An invitation to submit research proposals was published on 10 January 1989 in Official Journal C 4. Deadline for submission of proposals was 30 April.

Programme content

1. Models for energy and environment

2. Rational use of energy
   a. Energy conservation in end-use sectors
      — buildings
      — combustion technology
      — industry

   b. Energy supply and storage
      — fuel cells
      — high temperature superconductors
      — storage

3. Energy from fossil fuels (oil, natural gas, coal)
   a. Hydrocarbons (oil and gas)
      — exploration and reconnaissance
      — drilling
      — production techniques
      — support studies for offshore technologies
      — natural gas development and conversion
      — conversion of heavy fuels

b. Solid fuels
— pressurized fluidized bed combustion
— after burners
— circulating atmospheric fluidized bed combustion
— coal gasification
— generic R&D (e.g. coal-water mixtures)

4. Renewable energies
a. Solar-derived sources
— wind energy
— solar photovoltaic devices
— hydraulic energy
— biomass

b. Geothermal energy
— geothermal
— deep geology

Nemex '88, Birmingham, United Kingdom, 6 and 7 December 1988

The Commission was strongly represented at the 1988 British National Energy Management Exhibition and Conference, Nemex '88, organized in Birmingham by the Energy Systems Trade Association.

Clive Jones, Deputy Director-General for Energy, gave a presentation to the Conference on 'Introducing new energy technologies into the market — The European experience', outlining the future energy outlook, Community policies and, particularly, the achievements of the Community's demonstration programme. He went on to indicate the lessons learnt from the programme and the possibilities for the next phase after the expiry of the present programme at the end of 1989.

The Commission's Directorate-General for Energy took a very substantial stand at the Exhibition, comprising a Welcome Desk manned by Commission and British national (Energy Technology Support Unit) staff, brochures and posters, video recordings, and an on-line demonstration of the Sesame database. Over 100 enquiries were logged during the course of the two days, mostly from energy managers and technicians.

Many positive comments were heard, with people often expressing surprise at the range and scope of the Commission's activities in the energy field. One immediate spin-off was a meeting in London in February 1989 at which Commission staff explained DG XVII's activities to regional energy officers of the UK Department of Energy.

National laws and regulations relating to the natural gas industry in the EEC

The Commission of the European Communities has published a booklet on the laws and regulations relating to the natural gas industry in the EEC Member States.

This summary, available in French, English and German, is based on contributions from gas experts in the Member States.

It covers all the Member States, with the exception of Greece and Portugal which at present have no legislation on natural gas.

The booklet describes the laws and regulations currently applying to exploration, production, transportation, storage, distribution, imports and exports in the natural gas sector.

This booklet, published as EUR 11433, is available from the Office for Official Publications of the European Communities, L-2985 Luxembourg, price ECU 8.75.

Financial support for technological development projects in the oil and gas sector

On 8 December 1988, the Commission decided to grant support for 11 technological development projects in the oil and gas sector submitted in response to the call for applications published in the Official Journal C 210 of 7 August 1987.

A decision taken on 22 July 1988 had enabled support to be given to 46 of the 83 projects submitted in January 1988. As additional funds have become available, the Commission was able to increase support for five projects and make grants to six new ones. Of these 11 projects, five involve cooperation between companies in different Member States.

The projects affected by this supplementary decision are mainly in the area of production (7 projects), the other applications coming from the areas of exploration (1 project), pipelines (2 projects) and natural gas technology (1 project).

Taking this supplementary decision into account, the total aid granted in 1988 amounts to (see table):

Breakdown of support granted in 1988 to the various areas of technology

Area	Number of projects	Amount of support (ECU)	%
Geophysics and prospecting	8	6 630 225	15.90
Drilling	2	3 461 203	8.30
Production systems	23	21 033 965	50.45
Secondary and enhanced recovery	1	330 473	0.79
Environmental impact of offshore structures	6	3 713 090	8.91
Auxiliary and submersible vessels	4	1 687 663	4.04
Pipelines	4	2 443 720	5.86
Transport	1	168 000	0.41
Natural gas technology	2	1 626 416	3.91
Storage	0	—	—
Other	1	597 905	1.43
Total	52	41 692 660	100.00

Document update

Main Commission energy documents, proposals, directives

COM/88/0649	Council Regulation amending Regulation Nos 1893/79 and 2592/79 introducing registration for crude oil imports in the Community
CE./88/611	Council Recommendation of 8.11.1988 to promote cooperation between public utilities and autoproducers of electricity
C../88/2183	Commission decision of 30.11.1988 on the granting of financial support for demonstration projects in the fields of energy savings, alternative energy sources and substitution of hydrocarbons by use of electrical energy and heat
COM(89)121 final	European technologies for energy management: Thermie programme. Communication from the Commission and a proposal for a Council Regulation (EEC) concerning the promotion of energy technology in Europe.
COM(89)164 final	Evaluation of technological programmes in the field of energy. Communication from the Commission to the Council.
COM(89)123 final	Transparency of consumer energy prices. Communication from the Commission.

New energy publications

Industrial production. Quarterly statistics. No 3-4, 1988.
Luxembourg, Statistical Office of the EC,1988, 201 pp.

L'Opinion européenne et les questions énergétiques en 1987.
Ghestem, Catherine
Brussels, EC, 1988, 174 pp.

'The coal industry in the first half of 1988.'
Energy. *Rapid reports* No 10, 1988
Luxembourg, Statistical Office of the EC, 1988, 2 pp.

publicity announcement

PUBLICITY QUESTIONNAIRE

The Commission of the European Communities has decided to open up a number of its publications to outside advertising. To find out more, or if you would like to place advertisements, please fill in this questionnaire and return it to:

OFFICE FOR OFFICIAL PUBLICATIONS OF THE EUROPEAN COMMUNITIES
2, rue Mercier, L-2985 Luxembourg

COMPANY: ....

NAME: ....

ADDRESS: ....

.... Tel.: ....

1. From among the publications listed below, please indicate the ones in which you would like to place advertisements:

☐ Euro-abstracts, Section I
Euratom and EEC R, D&D projects
monthly — A4 format
EN

☐ Euro-abstracts, Section II
Coal and steel
monthly — A4 format
multilingual (DE/EN/FR)

☐ Catalogue of EC publications
quarterly and annual —
B5 format
ES, DA, DE, GR, EN, FR, IT, NL, PT

☐ Supplement to the OJ
Public contracts
daily — A4 format
ES, DA, DE, GR, EN, FR, IT, NL, PT

☐ EC Bulletin
monthly —
B5 format
ES, DA, DE, GR, EN, FR, IT, NL, PT

☐ Eurostatistics — Data
for short-term economic analysis
monthly — A4 format
multilingual (DE/EN/FR)

☐ European Economy
quarterly —
A4 format
DE, EN, FR, IT

☐ Energy in Europe
3 issues/year —
A4 format
ES, DE, EN, FR

☐ Social Europe
3 issues/year —
A4 format
DE, EN, FR

2. Frequency of placement:

   ☐ in each issue of the chosen publication

   ☐ irregularly: number of placements ....

   ☐ (a) in alternate issues ☐ (b) other (please specify): ....

3. Format of advertisement: ☐ 1 page ☐ ½ page

4. Are you interested solely in advertising in the publications appearing in your native language or in all Community languages?

   — Native language: ....

   — Other languages: ☐ ES ☐ DA ☐ DE ☐ GR ☐ EN ☐ FR ☐ IT ☐ NL ☐ PT

Date: .... Signature: ....

PLEASE NOTE:

The Publications Office reserves the right to reject advertisements it considers incompatible with the policy or aims of the Commission. The decision of the Publications Office is final.

Films (in very good condition) for offset printing must be supplied by the customer. The space taken up by the advertisement may not exceed the format indicated.

Venta y suscripciones · Salg og abonnement · Verkauf und Abonnement · Πωλήσεις και συνδρομές
Sales and subscriptions · Vente et abonnements · Vendita e abbonamenti
Verkoop en abonnementen · Venda e assinaturas

BELGIQUE / BELGIË

Moniteur belge / Belgisch Staatsblad
42, Rue de Louvain / Leuvenseweg 42
1000 Bruxelles / 1000 Brussel
Tél. 512 00 26
CCP / Postrekening 000-2005502-27

Sous-dépôts / Agentschappen:

Librairie européenne / Europese Boekhandel
Rue de la Loi 244 / Wetstraat 244
1040 Bruxelles / 1040 Brussel

Jean De Lannoy
Avenue du Roi 202 /Koningslaan 202
1060 Bruxelles / 1060 Brussel
Tél. (02) 538 5169
Télex 63220 UNBOOK B

CREDOC
Rue de la Montagne 34 / Bergstraat 34
Bte 11 / Bus 11
1000 Bruxelles / 1000 Brussel

DANMARK

J. H. Schultz Information A/S
EF-Publikationer
Ottiliavej 18
2500 Valby
Tlf: 36 44 22 66
Telefax: 36 44 01 41
Girokonto 6 00 08 86

BR DEUTSCHLAND

Bundesanzeiger Verlag
Breite Straße
Postfach 10 80 06
5000 Köln 1
Tel. (02 21) 20 29-0
Fernschreiber:
ANZEIGER BONN 8 882 595
Telefax: 20 29 278

GREECE

G.C. Eleftheroudakis SA
International Bookstore
4 Nikis Street
105 63 Athens
Tel.: 3226-323
Telex: 219410 ELEF
Telefax: 3254 889

Sub-agent for Northern Greece:

Molho's Bookstore
The Business Bookshop
10 Tsimiski Street
Thessaloniki
Tel. 275 271
Telex 412885 LIMO

ESPAÑA

Boletín Oficial del Estado
Trafalgar 27
E-28010 Madrid
Tel. (91) 446 60 00

Mundi-Prensa Libros, S.A.
Castelló 37
E-28001 Madrid
Tel. (91) 431 33 99 (Libros)
431 32 22 (Suscripciones)
435 36 37 (Dirección)
Telex 49370-MPLI-E
Telefax (91) 275 39 98

FRANCE

Journal officiel
Service des publications des Communautés européennes
26, rue Desaix
75727 Paris Cedex 15
Tél. (1) 40 58 75 00
Télécopieur: (1) 4058 7574

IRELAND

Government Publications Sales Office
Sun Alliance House
Molesworth Street
Dublin 2
Tel. 71 03 09

or by post

Government Stationery Office
EEC Section
6th floor
Bishop Street
Dublin 8
Tel. 78 16 66

ITALIA

Licosa Spa
Via Benedetto Fortini, 120/10
Casella postale 552
50 125 Firenze
Tel. 64 54 15
Telefax: 64 12 57
Telex 570466 LICOSA I
CCP 343 509

Subagenti:

Libreria scientifica Lucio de Biasio -AEIOU
Via Meravigli, 16
20 123 Milano
Tel. 80 76 79

Herder Editrice e Libreria
Piazza Montecitorio, 117-120
00 186 Roma
Tel. 67 94 628/67 95 304

Libreria giuridica
Via 12 Ottobre, 172/R
16 121 Genova
Tel. 59 56 93

GRAND-DUCHÉ DE LUXEMBOURG

Abonnements seulement
Subscriptions only
Nur für Abonnements

Messageries Paul Kraus
11, rue Christophe Plantin
L-2339 Luxembourg
Tél. 48 21 31
Télex 2515
CCP 49242-63

NEDERLAND

SDU uitgeverij
Christoffel Plantijnstraat 2
Postbus 20014
2500 EA 's-Gravenhage
Tel. (070) 78 98 80 (bestellingen)
Telefax: (070) 476351

PORTUGAL

Imprensa Nacional
Casa da Moeda, E.P.
Rua D. Francisco Manuel de Melo, 5
1092 Lisboa Codex
Tel. 69 34 14

Distribuidora Livros Bertrand Lda.
Grupo Bertrand, SARL
Rua das Terras dos Vales, 4-A
Apart. 37
2700 Amadora Codex
Tel. 493 90 50 - 494 87 88
Telex 15798 BERDIS

UNITED KINGDOM

HMSO Books (PC 16)
HMSO Publications Centre
51 Nine Elms Lane
London SW8 5DR
Tel. (01) 873 9090
Fax: GP3 873 8463

Sub-agent:

Alan Armstrong Ltd
2 Arkwright Road
Reading, Berks RG2 OSQ
Tel. (0734) 75 17 71
Telex 849937 AAALTD G
Fax: (0734) 755164

ÖSTERREICH

Manz'sche Verlagsbuchhandlung
Kohlmarkt 16
1014 Wien
Tel. (0222) 533 17 81
Telex 11 25 00 BOX A
Telefax: (0222) 533 17 81 81

TÜRKIYE

Dünya süper veb ofset A.Ş.
Narlibahçe Sokak No. 15
Cağaloğlu
Istanbul
Tel. 512 01 90
Telex: 23822 dsvo-tr.

UNITED STATES OF AMERICA

European Community Information Service
2100 M Street, NW
Suite 707
Washington, DC 20037
Tel. (202) 862 9500

CANADA

Renouf Publishing Co., Ltd
61 Sparks Street
Ottawa
Ontario K1P 5R1
Tel. Toll Free 1 (800) 267 4164
Ottawa Region (613) 238 8985-6
Telex 053-4936

JAPAN

Kinokuniya Company Ltd
17-7 Shinjuku 3-Chome
Shiniuku-ku
Tokyo 160-91
Tel. (03) 354 0131

Journal Department
PO Box 55 Chitose
Tokyo 156
Tel. (03) 439 0124

AUTRES PAYS
OTHER COUNTRIES
ANDERE LÄNDER

Office des publications officielles des Communautés européennes
2, rue Mercier
L-2985 Luxembourg
Tél. 49 92 81
Télex PUBOF LU 1324 b
CC bancaire BIL 8-109/6003/700

Price (excluding VAT) in Luxembourg: Single copy ECU 12.70/Subscription ECU 35

OFICINA DE PUBLICACIONES OFICIALES DE LAS COMUNIDADES EUROPEAS
KONTORET FOR DE EUROPÆISKE FÆLLESSKABERS OFFICIELLE PUBLIKATIONER
AMT FÜR AMTLICHE VERÖFFENTLICHUNGEN DER EUROPÄISCHEN GEMEINSCHAFTEN
ΥΠΗΡΕΣΙΑ ΕΠΙΣΗΜΩΝ ΕΚΔΟΣΕΩΝ ΤΩΝ ΕΥΡΩΠΑΪΚΩΝ ΚΟΙΝΟΤΗΤΩΝ
OFFICE FOR OFFICIAL PUBLICATIONS OF THE EUROPEAN COMMUNITIES
OFFICE DES PUBLICATIONS OFFICIELLES DES COMMUNAUTÉS EUROPÉENNES
UFFICIO DELLE PUBBLICAZIONI UFFICIALI DELLE COMUNITÀ EUROPEE
BUREAU VOOR OFFICIËLE PUBLIKATIES DER EUROPESE GEMEENSCHAPPEN
SERVIÇO DAS PUBLICAÇÕES OFICIAIS DAS COMUNIDADES EUROPEIAS

L-2985 Luxembourg

CB-BI-89-001-EN-C