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ON

THE NUCLEAR INDUSTRIES IN THE EUROPEAN UNION

(AN ILLUSTRATIVE NUCLEAR PROGRAMME ACCORDING TO ARTICLE 40 OF THE EURATOM TREATY)

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I. INTRODUCTION

1. The Illustrative Nuclear Programme for the Community (PINC)

Title Two of the Euratom Treaty is entitled "Provisions for the encouragement of progress in the field of nuclear energy". Chapter IV of this Title concerns "Investment", and Article 40 of this Chapter reads as follows :

> *"In order to stimulate action by persons and undertakings and to facilitate coordinated development of their investment in the nuclear field, the Commission shall periodically publish illustrative programmes indicating in particular nuclear energy production targets and all the types of investment required for their attainment.*
>
> *The Commission shall obtain the opinion of the Economic and Social Committee on such programmes before their publication."*

Since the Treaty was adopted, three illustrative programmes and one update have been published by the Commission respectively in 1966, 1972, 1984 and 1990[1].

In 1990 the Commission considered that the guidelines presented in the 1984 PINC[2] were mostly still valid, both as regards the nuclear-power production objectives for the Community, and the implications for all parties concerned : public authorities, electricity producers and nuclear industries.

The Commission also considered that all the interrelated aspects of nuclear power were covered by the overall energy policy. The 1984 PINC was one of the elements taken into account by the Council, when in 1986 it established the energy objectives for 1995[3].

It is the view of the Commission that it is now again appropriate to consider the main issues concerning nuclear energy, as foreseen by Article 40 of the

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[1] "The nuclear power station design and construction industry and completion of the European single market. Update of the Illustrative Nuclear Programme for the Community adopted by the Commission in 1984", COM(89) 347 final of 7 February 1990

[2] "Illustrative Nuclear Programme under Article 40 of the Euratom Treaty 1984" COM(85) 401 final of 23 July 1985, together with the opinion of the Economic and Social Committee of 30 May 1985, ESC 472/85

[3] Council Resolution of 16 September 1986 concerning new Community energy policy objectives for 1995 and the convergence of Member States policies (ref. OJ 86/C 241/01 of 25.09.1986)

Euratom Treaty, while keeping clearly in mind the constraints placed by that Article and by the Euratom Treaty as a whole.

Since the last PINC was adopted in 1984, the energy situation in the Community has changed and the energy market organisation is moving steadily towards liberalisation. Our knowledge of the environmental issues linked to energy use has advanced and we are now much more aware of the seriouness of climate change and the need for a global reduction in greenhouse gases emissions. The growing awareness of the crucial nuclear safety issues related to nuclear power plants in the Central and Eastern European Countries and the CIS, as well as the significant political changes in these countries which lead to a reinforced policy of disarmament, are also relevant factors. All these developments are affecting the future development of nuclear energy.

The Commission's intention with the 1996 PINC is to provide an overview of the situation in the European Union as regards nuclear energy and to indicate the importance it attaches to the nuclear issue. The 1996 PINC was announced in the recently published Commission White Paper "An Energy policy for the European Union"[4], and its content is placed within the framework of a common energy strategy, as presented in the White Paper.

As was clearly underlined in the White Paper, the Community is moving towards an integrated, liberalised, and more competitive energy market. The present Nuclear Illustrative Programme therefore takes a more market oriented approach than the previous ones. It also underlines the major challenges faced by the industry and addresses the main concerns voiced by public opinion.

Clearly, the nuclear issue is a highly controversial one in the Union, with many different views being expressed, in a context where Member States have different energy structures and different approaches to nuclear energy. The Commission believes that it is, nonetheless, important to update its views and promote the greatest degree of transparency possible on this issue.

2. The White Paper : An energy policy for the European Union

In its White Paper "An energy policy for the European Union", the Commission identifies three relevant objectives for the field of energy : overall competitiveness; security of supply; environmental protection.

As the Commission notes :

> *"In pursuing these aims the Community cannot be unaware that its forecast energy dependence will increase and that the choices to be made as regards protection of the environment in particular may heighten that dependence. Nor may it disregard the fact that the*

[4] COM(95) 682 of 13.12.1995

integration of the Community involves greater solidarity in the energy choices made by each of the Member States."

It is within this broader framework addressing global energy policy issues that future nuclear energy developments in the Community have to be addressed, while preserving the spirit of the relevant provisions of the Euratom Treaty. The aim of a policy providing a framework for the development of nuclear energy is to contribute to the achievement of the three energy policy objectives mentioned in the White Paper. The future of nuclear energy in the Community will depend to a large extent on its acceptability by society and by political leaders. The White Paper analyses the situation as follows :

"This acceptability problem derives particularly from concerns on nuclear safety, on transport and disposal of nuclear waste and on nuclear non-proliferation. The imperative of diversification, the external competitiveness of the nuclear industry and the integration of the electricity market in several Member States underline the role nuclear energy plays in electricity generation.

However, the reality is that a number of Member States depend to a large extent on nuclear energy, whilst others prefer to pursue a non-nuclear energy policy, and a third group have decided to reduce dependency on nuclear-based sources of energy or to terminate the existing nuclear-plants altogether.

The European institutions have responsibilities under the Euratom Treaty which permit the development of nuclear energy in conformity with the rules and policies at national level. The choice between energy technologies or fuels is always a matter where policy appreciation intervenes but nuclear should remain part of this choice."

The arguments developed in the White Paper are setting the scene for this new Nuclear Illustrative Programme. Its aim is to contribute to a reassessment of the various features of nuclear energy, in the European Union, as they are today and as they may develop in the future. Certain basic principles at Community level will be suggested as a conclusion to this paper.

Given that the development of nuclear energy has an important industrial dimension, at the level of electricity generation as well as the entire fuel cycle, the nuclear industry has an important responsibility to meet the challenges it will be faced with in the coming years. These challenges are described in this paper.

3. The role of nuclear energy in the Community and Worldwide

Today, the European Union has a mature nuclear industry covering the entirety of the fuel cycle, with its own technological base.

More than 140 nuclear reactors are operating in Belgium, Germany, Spain, France, the Netherlands, Finland, Sweden and the United Kingdom, making the Union the world's leading producer of nuclear generated electricity.

Nuclear power plants provide for approximately one third of the electricity generated in the European Community. The operational experience built up by the nuclear industry in Western Europe is at least equivalent, if not greater than that of the United States, Japan and other major industrial countries.

Large countries in Asia (China, India, South Korea) and in Central and Eastern Europe as well as in the CIS have chosen to include nuclear power amongst the means to meet their energy needs. Other Asian countries such as Indonesia, Thailand, Pakistan and Turkey have signalled their intention to also include nuclear power in their energy plans.

However, the USA has not granted a licence for building new nuclear power plants since 1974, although a significant number of plants are in operation and research activity is continuing. In Latin America, while countries such as Argentina and Brazil are encouraging the development of nuclear power generation, others have chosen not to follow a nuclear energy option.

II. THE NUCLEAR OPTION IN THE FRAMEWORK OF AN ENERGY POLICY FOR THE COMMUNITY

Any decisions made on nuclear energy at Community level need to be placed in the context of the overall energy policy decisions. The Community's responsibilities under the Euratom Treaty include the definition of common energy policy guidelines. Energy policy objectives in the context of the Union Treaty, have been discussed in the Commission's White Paper on energy policy. Policy decisions with regard to nuclear energy will need to be taken within the frameworks outlined in both the PINC and the White Paper,taking into account the industrial challenges identified. The fact that the acceptance of nuclear energy by public opinion differs from one country to another needs to be kept clearly in mind. It is also clear that absolute priority must be given to the safety of nuclear power.

As indicated in the White Paper, any Community energy policy should, at least, contribute to the achievement of the three fundamental objectives of :

- overall economic competitiveness;
- security of supply;
- environmental protection.

Nuclear energy will have to be judged according to these aims and the contribution it can make to the achievement of these energy policy objectives.

1. <u>Global Competitiveness</u>

a. *Production costs for nuclear-generated electricity*

According to a joint OECD / IEA study published in 1993[5], the breakdown in the total cost of nuclear-generated electricity production is as follows, assuming a 5 % average discount rate : initial investment 45 - 55 %, operation and maintenance 20 - 25 %, fuel 20 - 25 %. If an average discount rate of 10 % is taken, then the initial investment cost is 58 - 70 %, operation and maintenance 15 - 20 % and fuel 12 - 20 %.

For recently designed water-cooled reactors (the most widely used type in the Western world), the total cost of electricity production is estimated to be (at 1991 prices) 22 - 30 Ecus/1000 kWh assuming a 5 % discount rate, and 33 - 41 Ecus/1000 kWh assuming a 10 % discount rate.

Costs are higher for older water cooled reactors, for other types of reactors (for example gas-cooled reactors) or for Light Water Reactors which do not benefit from the lower costs of standardisation or of mass production. The investment cost for one such nuclear power station could be double the cost of a single nuclear power station which is part of a series.

Investment costs cover the basic construction costs, engineering costs, contingencies, decomissioning costs and long term decommissioning waste management costs.

Safety authorities in all the Member states using nuclear power oblige electricity generators to create a financial reserve fund for decomissioning and waste disposal, with the level of funds deemed appropriate by each Member State.

Decommissioning costs

Decomissioning costs vary according to the characteristics of the nuclear power station. Despite a certain degree of uncertainty involved in the estimates, current indications are that decomissioning represents a relatively low percentage of the total investment cost. It is currently estimated that the decomissioning cost for a 1000 MWe water cooled reactor represents 10 - 15 % of the total initial investment cost at constant prices, but it could be higher for other types of reactors. This percentage decreases after discounting (1.4 - 3.7 % for a 5 % discount rate, 0.2 - 2.1 % for a 10 % discount rate).

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[5] Entitled : "Projected costs of generating electricity-update 1992"
Results of this type of OECD study are based on replies to questionnaires given by Member States who have nuclear power stations.

Fuel costs

Fuel costs vary depending on the type of reactor, and on the option chosen for the fuel cycle. For a cycle with reprocessing the total fuel costs (1991 prices) is estimated at 4,6 Ecus/1000 kWh; for a cycle with a single use of fuel, the total cost is estimated at 4,1 Ecus/1000 kWh.

Waste, Transport and Disposal

According to a 1994 OECD report[6] for a fuel cycle with reprocessing, the cost for reprocessing, vitrification and waste disposal corresponds to 27 % of the fuel cost, while transport costs correspond to 1.5 - 2 %. For a single-use fuel cycle, transport and storage of irradiated fuel represents approximately 10 % of fuel cost, while coating and disposal of the irradiated fuel represents about 5 % of the cost.

Storage costs

A previous 1990 report[7] noted costs varying between 400 and 1,300 ECU / m^3 for storage of low level irradiated waste, and approximate discounted investment costs of 100,000 ECU / m^3 for high level irradiated waste storage.

Clearly, cost estimates are affected by the assumptions on which they are based and carry a degree of uncertainty, in particular as concerns waste treatment and storage. However, as indicated by the cited OECD cost estimates, even a significant variation in the cost of waste transport or storage will only have a small effect on the total cost of nuclear-generated electricity, since the nuclear fuel cost only represents 20 - 25 % of the total cost.

b. *Competitiveness of nuclear energy as compared to other energy source*

Industrial competitiveness refers to the production cost of the electricity generated (in kWh). This cost is the main factor in determining the price at which nuclear electricity is supplied to consumers, including heavy industries which are its main individual consumers.

The previously mentioned joint study of the OECD and of the IEA from 1993 compares the projections of costs of the various sources of electricity production on the basis of data provided by the Member States, using the method of the levelized average cost. This study

[6] The Economics of the Nuclear Fuel Cycle NEA / OECD - 1994

[7] Report EUR 12871 "Evaluation of Storage and disposal costs for conditioned radioactive waste in several European countries"

shows that, on the basis of an average discounted costs at the rate of 5% a year, nuclear power appears to be the most economic option in thirteen of the fifteen countries examined (the exceptions being the UK and NL). For a rate of 10%, five countries keep a real economic advantage to use nuclear power; five others preserve the choice between nuclear power and natural gas. These conclusions rely on the implicit hypothesis of price stability for the fuels, by no means guaranteed owing to the increasing demand for natural gas. They also include costs of decommissioning and waste disposal. It is envisaged that this study will be updated in 1997.

Another study of the OECD published in 1992 examines the overall economic impact of the use of nuclear energy. The economic analysis conducted for the countries having opted for nuclear energy shows clearly beneficial effects on the balance of payments due to the savings made on energy imports. Of course, the economic attractiveness of nuclear generated electricity depends on a wide range of factors and it is therefore not surprising that different studies give rise to divergent results.

Developments towards the liberalisation of the Community internal electricity market will mean that nuclear energy will have to compete in the same framework and under the same conditions as all other energy sources. A full implementation of the internal market and a rigorous application of the relevant state aid and competition rules implies a level playing field for all energy sources, with emphasis on cost transparency.

In terms of raw material costs, whatever the future trends in the price of uranium or exchange rates, they are likely to have a rather low impact on the competitiveness of the nuclear industry since the purchase cost of the source material currently accounts for considerably less than 10 % of the electricity production costs. The remainder of the production cost is mainly accounted for by technological and industrial input from within the European Union. The Union has the necessary expertise in nuclear technology, and the capability to improve this technology even further.

It should be noted that, due to the capital intensity of the nuclear industry, its economic attractiveness depends critically -inter alia- on the level of interest rates. It should also be noted that costs and pricing of nuclear generated electricity are likely to be re-evaluated in the light of moves towards the liberalization of electricity markets and in certain cases privatisation (for example in the UK).

c. *Exports*

Industrialists and manufacturers involved in the nuclear fuel cycle or in the construction of nuclear power stations make a considerable contribution to the European Union's export earnings. There are also growing export opportunities for European business in the large, global nuclear waste-treatment and decommissioning markets.

Export markets are essential for maintaining the technological level and know-how acquired by European industrialists, in particular those operating in fuel cycle activities or in equipment manufacturing. The Commission has negotiated and is negotiating, nuclear agreements with third countries, in order to facilitate business and trade in nuclear goods and services.

It should be noted that all nuclear exports from the Union are subject to the IAEA rules, as well as the Euratom safeguards regime.

d. *Long term lasting investments*

The nuclear industry investments are made for the long term. To be realised they need a long lead time and a stable and favourable regulatory and economic environment. It takes 5 to 10 years to design and construct a nuclear power station, which is then operated and maintained over a period of 40 years or more. The operator needs the assurance that fuel and fuel services will be available throughout this period and that it will be possible to process the spent fuel and nuclear waste in a satisfactory manner.

In implementing the internal electricity market, Member States may take due consideration of the long term planning needs of the nuclear industry and create, accordingly, the conditions for such heavy long term investments.

e. *Qualified indigenous employment*

More than 90 % of the cost of nuclear energy arises from services provided by economic operators within the European Union. It follows that considerable use is made of indigenous labour, whether directly or indirectly. This level of employment is generated or maintained by investment in the various branches of the industry which contribute to nuclear energy production, and by the operation of the plants when built.

The nuclear industry estimates that it employs more than 400 000 staff in Europe in tasks directly linked to electricity generation and fuel cycle activities, mostly highly-qualified, making an important contribution to the economic, social, industrial, and scientific development of the European Union.

f. *Innovation and technological development*

It has been recognized from the beginning in the Euratom Treaty that the development of nuclear energy would not have been possible without major breakthroughs in research and development. The nuclear industry has been consistently successful in terms of innovation and implementation of new technologies. The nuclear research effort needs to be continued, in parallel with research in renewable energy sources and efforts to increase energy efficiency. Support of the Research and Development Community Framework Programmes, together with national programmes, will contribute to the further improvement of safety, to the effectiveness of the industry and to the creation of new export markets.

2. <u>Security of supply</u>

a. *Emerging energy trends in the European Community*

As indicated in White Paper, future energy supply and demand trends are difficult to predict. Different scenarios have been studied, examining a range of different possible socio-economic futures at the horizon of 2020[8]. In this study,

> *"Some of the key messages emerging which may have policy implications are as follows :*
>
> - *Europe will significantly increase its dependence on imported energy;*
> - *gas will compete with oil as a leading component of the fuel mix;*
> - *European consumers will become increasingly dependent on "grid" supplied energy;*
> - *there is considerable flexibility as to the final shape of the future fuel-mix. The weight given to climate change concerns, the effect of technology and the liberalisation of markets and the fact that some renewables are on the threshold of economic viability will be the major determining factors."*

Based on these key messages, nuclear energy can continue to play a role in the future supply of energy to the European Community. This would be particularly useful if the present satisfactory degree of supply diversification deteriorates in the coming years, as some experts expect.

We must therefore keep trying to save energy, to diversify our resources and to maintain a high degree of self-sufficiency. In spite of their widely

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[8] European Energy to 2020 : A scenario approach. Ref. : SEC(95) 2283 of 20.12.1995

differing national policies, the Member States of the Community must act together to alleviate energy supply constraints. Nuclear energy can be a way to contribute to that aim.

b. *Growing world energy demand*

Since the energy markets are international, there is also a need to look at the energy situation world-wide.

With a near stagnation of energy demand in Europe and a decline in the former Soviet Union, it is easy to overlook that energy demand is rising very quickly in Asia. Future population growth and development in Third World countries will also generate an increase in their consumption of fossil fuels. According to the Commission's scenarios studies mentioned above, total world energy demand could grow by around 50 % between now and the year 2020. Coordinated efforts to improve energy efficiency, promote savings and develop renewable sources of energy would lead to a smaller increase in world fossil fuel demand for the future.

When it comes to meeting that demand, world fossil fuel reserves are far from being inexhaustible. According to the latest estimates from the World Energy Council, on the basis of current consumption, oil reserves (75 % of which are controlled by OPEC) may last for just over 40 years, natural gas for the about 65 years, coal for over 200 years and uranium for about 25 - 30 years if no fuel reprocessing is carried out (with fuel reprocessing the life time of uranium reserves is extended manifold). However, fossil fuel reserves have frequently been underestimated in the past because little account was taken of improvements in yield recovery techniques. Over the past twenty years, proven fossil fuel reserves have been fairly stable and in certain cases even increased, despite high and growing consumption volumes, and there has been no reason in recent years to look for major new uranium reserves. It should also be noted that uranium reserves are widely dispersed in a number of countries. Oil prices, at their lowest level since 1973, may well rise in the medium term. The prices of uranium available on the international market have been going down due to supplies from the CIS countries, but the trend is reversing. However, if a recycling option for nuclear fuels (plutonium) is followed, there will be less need for uranium.

Having taken all the factors into account, use of nuclear energy is considered by some of the potentially highest energy consuming countries in the world as a way of facing their energy supply problems. On the other hand, because of the uncertainties involved, a number of countries have chosen not to build nuclear plants and to pursue other forms of supply diversification.

c. *Peculiarities of nuclear fuels*

The way in which nuclear fuels are used differs from other fuels. Uranium is mined virtually only for the purpose of energy production. More importantly, once the waste products of its initial use have been removed, uranium and its by-product plutonium can be recycled and used for further energy production.

Since only a small fraction of the potential energy in uranium is consumed during its first use, it makes sense in the long term to recycle it, and even to do so repeatedly, provided technological solutions are found to make recycling safe and economically viable.

Nuclear material (plutonium) obtained from the dismantling of weapons may also be recycled as nuclear fuel for power generation. Plutonium in all its forms raises issues in the areas of environmental safety and non-proliferation. For recycling, there are still questions concerning its economic viability.

d. *Non proliferation and nuclear safeguards*

There is an evident link between nuclear trade and enhanced security of energy supply, and the non proliferation credentials of a country or a group of countries. Non proliferation is of prime importance, given the possibility of using highly enriched uranium or plutonium of any grade as fissile materials for nuclear weapons.[9] The European Union has contributed significantly to the development of non-proliferation mechanisms.

Euratom is the regional organization with the longest experience in safeguards and non-proliferation. Its activities are closely connected with the letter and the spirit of the NPT, in particular as regards the interrelation between a regional and a global safeguards system, and the link between regional and global cooperation for the peaceful use of nuclear energy.

Euratom is a prominent example of a regional integrated safeguards system : it is based on European Community law and is operating efficiently and effectively. A new partnership arrangement has been agreed in 1992 between the Commission and the IAEA (International Atomic Energy Agency) known as the "New Partnership Approach", in order to optimise resources and to strengthen safeguards.

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[9] Isotopic separation is needed to enrich uranium to the level needed for weapons, while the chemical separation needed to obtain plutonium represents a lower barrier to diversion for military purposes.

The objective was to strengthen cooperation between the two organizations, based on the following understanding :

- Euratom is confirmed in its role as a regional system sui generis;
- mutual support in Research and Technological Development is regarded as essential;
- support in logistics will be enhanced;
- common training and equipment procurement will be developed;
- inspection arrangements will be optimized in order to enable the IAEA to save inspection resources;
- each organization will maintain its rights to draw independent conclusions.

The experience gained so far with the implementation of this new approach is judged as being positive.

The European Union supported fully the indefinite and unconditional extension of the Non-Proliferation Treaty (NPT) and the results of the NPT Review and Extension Conference held in 1995 are therefore considered to have been a success.

It should be noted in this context that the Nuclear Summit of Moscow on 19-20 April 1996 confirmed the commitment of the G7 and Russia to conclude a treaty on the total ban of nuclear tests (CTBT) which was signed in September 1996.

It should also be noted that, since 1992, all exports of nuclear material from the European Union to third countries which do not possess nuclear weapons, are subject to the IAEA's full scope safeguards.

The European Union is thus a major player not only in trade in nuclear materials and equipment, but also in the important areas of non-proliferation and nuclear safeguards.

3. <u>Protection of the population and the environment</u>

Broadly speaking, for the first 20 years of the existence of Euratom there has been a consensus on the usefulness of nuclear energy. This consensus, weakened after the accident at Three Mile Island and partly broke down following the Chernobyl accident, though the design and safety features of this plant cannot be compared with those of nuclear power stations operating in the European Union. It is now internationally accepted that use of nuclear energy and ensuring its safety are two sides of the same coin. Countries using nuclear energy must put "safety first".

a. *Basic safety standards for radiation protection and human health protection*

Article 2(b) of the Euratom Treaty requires the Community to "establish uniform standards to protect the health of workers and of the general public and ensure that they are applied" as provided in the Treaty.

Under article 31 of the Euratom Treaty, basic standards have been laid down establishing the fundamental principle of radiation protection and the maximum permissible radiation doses for workers and the general public. These standards, updated in 1996, form the basic framework for radiation protection throughout the European Union[10].

In addition, the provisions of article 129 of the Treaty on the European Union state that the Community shall contribute towards ensuring a high level of human health protection, and that health protection shall be a constituent part of other Community policies.

b. *Reduction of CO_2 and other harmful emissions*

The build-up of CO_2 in the atmosphere poses a serious threat, and less use will have to be made of coal and other fossil fuels. Although Europe uses energy more efficiently than the USA, China or Russia, it can still reduce CO2 and other emissions, by promoting, for example, energy savings and the use of renewable sources of energy. The use of nuclear energy has the advantage of reducing CO_2 and other greenhouse gas emissions. It should be noted that, for Europe as a whole, use of nuclear energy is already avoiding the emission of some 700 million tonnes of CO_2 annually, compared to a situation where the same electricity would have been produced using a mix of fossil fuels[11].

In addition, nuclear power generation contributes to the avoidance of other harmful atmospheric emissions such as particulates, sulphur dioxide, nitrogen oxides and methane.

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[10] Council Directive 96/29/EURATOM of 13 May 1996 laying down the basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation (OJ L159 of 29.06.1996)

[11] European Energy to 2020 : A scenario approach. Ref. : SEC(95) 2283 of 20.12.1995

c. *Environmental impact assessment and emergency preparedness*

Specific provisions in the Euratom Treaty also exist (art. 35-37) in order to assess the radiological impact of the release of radioactive materials into the biosphere. Nuclear installations are designed and built to contain virtually all the harmful by-products of their operation, even under accidental conditions. However, this is not the way in which the general public perceives the inherent risk of radioactivity being released as the result of the use of nuclear energy -either under normal operating conditions or in the event of an accident.

Industrial nuclear installations in the European Union are well assessed for their impact on the environment. They must meet the specific provisions of the Euratom Treaty and its secondary legislation, and are also covered by the Council Directive on environmental impact assessment[12] and the ESPOO Convention (Convention on Environmental Impact Assessment in a Transboundary Context).

As required by the Community basic standards, emergency programmes have been developed in all Member States in order to ensure that public authorities will be able to cope in an appropriate way with the possible radiological consequences, in case of a nuclear accident. These programmes are co-implemented by a Community system for the rapid exchange of information established on the basis of a 1987 Council Directive[13]. These programmes provisions will benefit from the common approach of the RODOS system, which is being developed as a decision-aiding system for offsite response to nuclear emergencies and is being implemented in certain Member States and elsewhere mainly through the Radiation Protection Research Programme.

In the event of a nuclear accident having off-site consequences, it is important that the public affected is sufficiently informed about the appropriate behaviour to adopt. A 1989 Council Directive deals with the information of the general public concerning the health protection measures to be applied and steps to be taken in the event of a radiological emergency[14].

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[12] Council Directive (85/337/EEC) of 27 June 1985 concerning the evaluation of the impact of private and public projects on the environment (OJ L175 of 05.07.1985)

[13] Council Directive 87/600/EURATOM of 14 December 1987 on Community arrangements for the early exchange of information in the event of a radiological emergency (OJ L371 of 30/12/87)

[14] Council Directive (89/618/EURATOM) of 27 November 1989

d. Radioactive waste management

Radioactive waste management is an important factor in safety and environmental protection. Industrial techniques for the management and disposal of nuclear wastes are being implemented and constantly improved. Nevertheless, research needs to be continued in a systematic way, in order to further reduce the volume of waste to be managed and to optimise the technologies used in waste management.

In 1994 the Commission adopted a Communication proposing a "Community strategy for the management of radioactive wastes"[15]. This strategy, which is basically focussed on safety and environmental protection concerns, envisages a harmonised approach concerning radioactive waste management principles at Community level, where practicable, in order to ensure an equivalent level of safety throughout the Community. It represents a comprehensive medium and long-term programme, but concentrates only on those elements which could benefit from a common approach to radioactive waste at Community level. These elements include the definition and classification of radioactive waste; waste minimization, transport, treatment and disposal; public information; and financing of radioactive waste management.

There is a consensus on the approach adopted in this field between the Community and the specialised international agencies involved, namely the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency (NEA) of the OECD. This consensus would be strengthened by the adoption of an international convention on the management of radioactive waste. Preparation of a draft text has already started within the framework of the IAEA. The Commission fully supports this ongoing process.

e. Technological issues of nuclear safety

In 1975, the Council of Ministers adopted its first Resolution on "The technological problems of nuclear safety"[16]. That Resolution remains important for the promotion of cooperation in the field of nuclear safety. Nuclear technology issues which are directly related to nuclear safety are not subject to prescriptive provisions in the Euratom Treaty. The Resolution set the basis for a freely agreed cooperation between Community Member States and the Commission on the technological and industrial issues which are significant for the safety of nuclear installations. It calls for "the progressive harmonisation of safety requirements and criteria in order to provide for an equivalent and

[15] COM(94) 66 final of 02.03.1994.

[16] Council Resolution of 22 July 1975 (OJ C185 of 14.08.1975)

satisfactory degree of protection of the population and of the environment against the risk of radiation resulting from nuclear activities and to assist the development of trade".

On the eve of the target date for the completion of the Union's Internal Market (1993), the Council consolidated the basis for cooperation between Member States and the Commission on the technological problems of nuclear safety by adopting a further Resolution on 18 June 1992[17]. This Resolution provides guidance on ways of seeking consensus throughout the Union on key safety requirements. Consensus on such requirements will be beneficial to any harmonisation effort related to materials and manufacturing codes and standards, significant for the mechanical integrity of plant components. The 1992 Resolution also calls for coherence between harmonisation of safety criteria and requirements within the European Union, and the Union's programme of cooperation with non-Member States.

III. SAFETY PROBLEMS IN THE COUNTRIES OF CENTRAL AND EASTERN EUROPE AND IN THE CIS

The Chernobyl accident in 1986 revealed important deficiencies in the design, construction and operation of reactors and, more generally, in the safety culture prevailing in the countries of that region. The seriousness of the situation was underestimated for several years by the authorities at the time. Only in the early 1990s, following the political changes, did it become apparent that urgent action should be taken to improve the oldest reactors and even to make it possible for the operating countries to close them down.

Accordingly, the G-7 countries committed themselves, at their Economic Summit in 1992 in Munich, to an action programme which was adopted by the G-24 as the basis for all technical assistance efforts in the area of nuclear safety. The European Union, for its part, undertook to use the technical assistance provided for under the PHARE programme for the Central and Eastern European countries including the Baltic countries and under the TACIS programme targeted at the CIS countries.

Such an assistance was developed mainly in the following fields :

- support to safety authorities
- design and operational assistance
- spare parts
- waste treatment and fuel cycle
- early warning systems
- Chernobyl

[17] Council Resolution of 18 June 1992 (OJ C172 of 08.07.1992)

As a primary objective, short term measures are implemented and drawn up to remedy the most urgent deficiencies, especially as regards the less safe reactors, and to transfer our safety culture. Longer term measures are also implemented and drawn up aiming at bringing the reactors, either existing or under construction, as well as other nuclear installations to an internationally accepted safety level.

Euratom loans may offer today a way of financing the necessary investments.

The implementation of such programmes presupposes that all Central and Eastern European countries and the CIS take swift action to introduce a nuclear civil liability system as defined in the Paris and Vienna Conventions, thus enabling the European nuclear industry to give them its support within a satisfactory legal framework.

Implementation of the European Energy Charter principles will be realised through the "Energy Charter Treaty", a binding instrument applicable to all forms of energy which was available for signing from December 1994 to mid June 1995. At the signature closing date, 50 countries and the European Communities had signed the Treaty, among which all European countries and some of the OECD countries, with the exception of the USA and Canada. A Declaration concerning peaceful uses of nuclear energy is still under consideration.

IV. THE ROLE OF THE COMMISSION IN RELATION TO ARTICLE 40 OF THE EURATOM TREATY

1. Actions to facilitate nuclear investments

In general, as stated in Article 40 of the Euratom Treaty, the Commission's role is "to stimulate action by persons and undertakings and to facilitate coordinated development of their investment in the nuclear field". Although decisions are taken by the Member States, the Commission can facilitate their strategic choices, thus enabling the European Union to derive the maximum benefit from the safe use of nuclear energy.

Examples of actions undertaken by the Commission are the promotion and encouragement of a speedy harmonization of requirements, rules, criteria and practices regarding the design, operation, maintenance and certification of installations.

2. Review of developments in the nuclear field

Forty years after the signature of the Euratom Treaty, its implementation requires the Commission to acknowledge the fact that nuclear energy is an industrial, economic and social reality in several highly-developed countries and that the nuclear industry in Western Europe has reached its mature years.

The nuclear generation installed capacity in the European Community was of 120 GWe in 1995. According to the current plans of Member States, it will still increase slightly to reach 125 GWe in 2000.

While no precise plans are available for a later date, the scenarios developed by the Commission[18] predict a possible range of installed capacity between 118 and 138 GWe for 2010, based on certain long term assumptions. These assumptions concern, for example, the future price of energy, the intensity of energy efficiency, the political choices to be made by Governments, etc. Under these circumstances, the Commission considers that it is not feasible to assign quantitative production or investment targets to the nuclear industry beyond the year 2000, noting, in addition, that the Union's objective today is to let market rules play their role.

If, in the future, economic or political pressures modify the present framework, a longer term approach may be needed again. For example, if new political choices are made in order to combat greenhouse gases emissions, it may as a result be envisaged to establish nuclear electricity production targets at a more distant horizon.

In any case, there is a need to improve cooperation between Member States in the nuclear field and to identify the major challenges that the nuclear industry will be faced with in the future.

The Commission therefore proposes to examine, in the remaining parts of this document, the main features of and challenges for the nuclear energy sector in the years to come, and to suggest certain principles to be followed at Community level for the peaceful use of nuclear energy.

V. THE EUROPEAN NUCLEAR ENERGY INDUSTRY : MAIN FEATURES AND CHALLENGES

In the years to come, the world will be faced with increasingly difficult environmental energy-related problems. Nuclear energy is one of the means of generating large quantities of electricity economically, without depleting the planet's reserves of fossil fuels.

1. Nuclear industry activities and business opportunities

At present, in the European Community, the scope for construction of new nuclear power stations is rather limited. However, investment programmes exist for the replacement or modernisation and upgrading of operating plants. Research programmes for the development of a new generation of reactors have also been undertaken. These programmes will, in principle, permit the

[18] European Energy to 2020 : A scenario approach. Ref. : SEC(95) 2283 of 20.12.1995

nuclear industry to further develop its technological and research base and its development skills and, where possible, to further improve its competitiveness and know-how.

The situation is different for some of our competitors. In Japan in particular, prospects for new developments exist, and in order to exploit these prospects, Japanese firms have formed strong links with North American industrial firms. The rapid economic development taking place in the Far East makes it also a growing market. The European industry must be ready to grasp every opportunity to operate in these countries. Fuel cycle expertise developed by European Union companies is already being exploited in the growing Far Eastern markets. Major opportunities also exist in the huge waste management and decommissioning markets, especially in the USA.

The European Union has committed itself, in the framework of cooperation with third countries, to ensure that absolute priority is given to safety when using nuclear energy ("the safety first" principle). The Union has committed itself in particular to cooperate for the promotion of a safety culture in all countries which have nuclear reactors; to an increased international transparency in nuclear activities; and to the continuation of the reform in the energy sector in countries in transition, on the basis of effective strategies orientated towards an opening to the world and towards adoption of corresponding economic and environmental principles.

The industry must also be in a position to cooperate with Central and Eastern European Countries and the CIS within this framework, provided the financing is adequate and a civil liability system is available in accordance with international rules. The involvement of the European industry could ensure that internationally accepted safety standards are respected. There is also a need for all nuclear States to participate in the existing nuclear liability conventions (the Paris/Vienna Convention) as a means of providing full legal security, both to the nuclear industry and to European citizens.

2. Nuclear fuel supply conditions

In the short and medium terms, there is no foreseeable risk of supply disruption of uranium or of enrichment services. However, in recent years the substantial increase of the share of the natural uranium market captured by the CIS, through prices at abnormally low levels (well below market economy costs of production), has caused serious concerns to the European nuclear fuel industry and has resulted in substantial reductions in uranium production in the Community and in the Community's traditional market economy supplier countries. Furthermore, nuclear material from dismantled weapons has the potential of aggravating the problems of market instability for natural uranium and overcapacity for enrichment. The Commission and the Euratom Supply Agency are applying a policy of diversification of sources of supply, implemented in a flexible way by the exercise of the Agency's right to conclude contracts and aiming at avoiding overdependence on any single source of supply. The Commission is also exploring whether possible solutions can be found in cooperation with the main states concerned.

More recent initial signs of firming uranium prices may mean that the mining industry will begin again to make the investments necessary to cover world requirements for uranium towards the end of the century. There are already indications that production has increased in Australia, the US and Namibia, and has been maintained at a high level in Canada. However, this trend has still to be confirmed.

The Union supports cooperation programmes for the safe storage of fissile material released by the dismantlement of nuclear weapons, its peaceful use and its safe and secure transportation.

3. <u>Technological challenges of nuclear safety</u>

The Council Resolutions on the Technological problems of nuclear safety (1975, 1992) referred to in section II.3 (e) are implemented through the following three complementary actions :

i. Efforts to establish consensus amongst nuclear plant operators, designers, manufacturers, regulators and technical support institutions on technical issues which are key in operational and design safety;

ii. A concerted effort between Member States and the Commission for the safety assessment of important European nuclear plant projects;

iii. The establishment of equivalence regarding safety for those technical codes which are significant for the mechanical integrity of nuclear plant components.

The combination of these actions should contribute towards finding consensus on key safety requirements, thus avoiding technical barriers to the free movement of goods and services. These actions should also strengthen the harmonisation effort on technical codes, taking early account of safety requirements. The Commission's standing advisory expert groups on reactor safety, regulators and mechanical codes and standards provide a forum for on-going communication and cooperation between the relevant actors.

Another objective of the 1992 Resolution is to ensure coherence between the use of best nuclear safety practice in the European Community and the transfer of know-how to Central and Eastern European Countries and the Community of Independent States through the Community's technical cooperation and assistance programmes. These programmes are based on a transfer of know-how, a transfer of the safety culture and, subsequently, a transfer of equipment. In the period between 1991 and 1995, the European Union committed 555 Mio Ecu for projects in the CEEC and the CIS. It is the intention to allocate similar average annual budgets to this sector over the period 1996-1999. Efforts for the effective transfer of European Community best safety practice are made through the promotion of contacts between East and West-European partners: operators, designers, manufacturers, technical support organisations, regulators. Joint expert groups can provide appropriate fora for communication and cooperation on nuclear safety.

In a wider context, an important initial step has been taken to address the safety problems worldwide, by drawing up an international convention on nuclear safety within the framework of the IAEA. Under this convention, the contracting parties commit themselves to comply with fundamental principles adopted on the basis of a consensus between world experts, and this can be verified. As many States as possible should therefore be encouraged to ratify and apply this Convention.

4. <u>Spent fuel, nuclear waste and decommissioning</u>

Industrial processes exist for nuclear waste treatment, the decommissioning of nuclear plants at the end of their life span and the reprocessing of spent fuel.

There are different ways to manage spent fuel. One way is to put spent fuel into retrievable storage disposal. A second way is to reprocess spent fuel rods chemically removing the plutonium and the uranium, to vitrify the resulting waste and to put the vitrified waste into storage. These solutions are being studied in several countries. Another possibility is to bury unprocessed spent fuel into deep permanent storage facilities.

Under the first and third approach, all the elements present in such spent fuel, including plutonium and slightly enriched uranium, are considered as waste. In the second approach, by recycling the re-usable plutonium and slightly enriched or depleted uranium, the volume of high-level waste for final disposal is reduced.

Storage and disposal methods are constantly being improved through research and demonstration programmes, and these should be pursued systematically.

There is some experience already in the Community in the field of decommissioning based on a number of specific cases, for instance the nuclear power reactors Gundremmingen-A and Greifswald in Germany, Chinon-A and St. Laurent-A in France, Windscale AGR and Berkeley in the United Kingdom, Vandellos I in Spain and the reprocessing facilities AT-1 in France and Eurochemic in Belgium. However, so far, most aged power plants have been modernized and upgraded, extending the life-span of the investment, and have not yet been decommissioned. Where new nuclear power plants are being designed in the European Union and the USA, attention is being paid to reducing the cost of their future decomissioning.

5. Transport of radioactive materials

A safety policy is pursued in all Member States with regard to the transport of radioactive materials. There have been regular Commission reports in accordance with a 1992 Council Directive on radioactive waste shipments[19].

An additional report describing the provisions adopted and implemented in order to ensure an appropriate radiation protection for the public and the environment has been adopted recently by the Commission[20]. It covers the transport of radioactive material resulting from all activities, including medicine, the latter accounting for most of the packages shipped.

The report concludes that "packages of radioactive material shipped worldwide each year have been transported safely" and that "the excellence of these results can be put down to the existence of stringent, uniform regulations that have been rigorously enforced for several decades, and the adequacy and implementation of which are regularly being reviewed and updated by groups of experts". Such an excellent safety record cannot, however, give cause for complacency.

6. Use of plutonium

In France, Belgium, Germany and Switzerland, plutonium obtained from the reprocessing of irradiated fuels has been and is successfully recycled in light-water reactors. Power station operators are satisfied with the results[21].

Fast neutron reactors are theoretically capable of incinerating plutonium, including weapons-grade plutonium made available by the dismantling of nuclear weapons -although they have not yet been tested in such a role, but research is currently going on. Fast neutron reactors can also be used to reduce the quantities of radioactive waste made up of heavy elements known as actinides.

The challenge facing the nuclear industry is to ensure that plutonium recycling is safe and economic.

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19 Council Directive 92/3/EURATOM of 3 February 1992 on the supervision and control of shipments of radioactive waste between Member States and into and out of the Community.

20 Communication to the European Parliament and to the Council on the safe transport of radioactive materials in the European Union : COM(96) 11 of 20 March 1996

21 Although the United States operate about 110 large power producing reactors, the spent fuel is not reprocessed, following a decision to renounce to plutonium-based fuel cycle taken by the Carter Administration in the 1970's. On the other hand, Japan intends in the near future to undertake the recycling of plutonium as a fuel for their nuclear power plants.

Currently, the cost associated with reprocessing, handling and turning plutonium into MOX fuel make it more expensive, on a purchase price basis, than low-enriched uranium (LEU). However there are many other considerations that determine fuel choice in this sector.

The presence of plutonium in the civilian nuclear fuel cycle has important implications for worldwide non proliferation policy.

7. Future nuclear technology, research and development

In order to face all new challenges and to answer to public concerns, the role of research has been underlined several times by the European Parliament, the Council and the Commission.

The Euratom R and D Framework Programme (1994-1998)[22] stressed that it is necessary to consolidate the nuclear option by showing our ability to control it in all areas of application. This demonstration of a full nuclear safety capability will be continued through the following priority routes :

- the development of a dynamic approach to nuclear safety;
- the joint use of the large European test facilities;
- the creation of a common understanding of the crucial phenomena linked to the nuclear fuel cycle;
- the development of means to prevent and mitigate severe reactor accidents;
- the establishment of the scientific and technical basis for the long-term safety of radioactive waste disposal;
- the pursuit of the development of nuclear safeguards techniques;
- the integration of radiological protection into a global system for the protection of man and the environment.

New systems of control and monitoring, aspects related to severe accidents, work on new safety features for innovative reactors, ageing of installation, safety of the fuel cycle and waste management, as well as nuclear safeguards

[22] Decision 1110/94/EC of the European Parliament and the Council of 26 April 1994 concerning the forth framework programme for Community activities in the field of research, technological development and demonstration for the period 1994 to 1998 (OJ L126 of 18.05.1994)

are amongst the activities to be implemented either through indirect actions or by the Joint Research Centre.

For the near future, a new generation of reactors is under development, with the clear objective of taking on board the latest developments in the area of safety. The European Pressurized Water Reactor (EPR), is one such reactor developed by European industry. The aim is to design a high power nuclear generating plant, economically viable able to comply with the requirements of the safety authorities. The EPR is in the detailed design phase, with the construction of a prototype expected in two or three years time.

The development of fast neutron reactors (FNR) is continuing at a slow pace. This is due to a number of problems being encountered in the handful of such reactors undergoing tests in France, Japan and Russia. FNRs may eventually be able to mass-produce electricity in Europe once the current technical problems are overcome. If this proves to be the case their use may offer some advantages in terms of waste treatement and disposal, as noted above in this document.

At present, thermonuclear fusion is a huge technological project involving the European Union and Switzerland. It offers an important potential for the very long term energy future but absorbs a large share of the public budgets devoted to Research and Technological Development.

Given the extreme difficulty of developing fusion technology, the European Union has also chosen to work in cooperation with major world partners (USA, Japan and Russia) under the ITER (International Thermonuclear Experimental Reactor) Agreement.

VI. CONCLUSION

The management of nuclear energy, including the issues of spent fuel, waste disposal and decommissioning, as well as the other challenges identified for the future, are the priority objectives of the regulatory authorities, the nuclear industry and other organisations concerned.

Use of nuclear energy produces favourable impacts on security of energy supply, fuel imports, high technology know-how, qualified jobs, and CO_2 emissions reductions. On the other hand, there are problems related to concerns on safety, transport, management of waste, decommissioning and non-proliferation. All are areas to which much consideration must be given and which will continue to merit careful attention at all times. Further technological development and increased international cooperation is also important.

Almost forty years after the signing of the Euratom Treaty, the European Community has a mature nuclear industry covering the entire fuel cycle with its own technological base. Certain Member States have decided not to produce nuclear energy and some others have decided to plan the decommissioning of their nuclear power plants. However, the European Union and some of its Member States may, in the context of a future energy supply strategy, review the role of nuclear energy alongside of other alternatives.

Future discussions as the role of nuclear energy will be affected by whether circumstances confirm an ever increasing dependency of the Community on fossil fuels imports to meet future energy supplies.

Use of nuclear energy for the production of electricity contributes to reducing fossil fuel consumption; the subsequent reduced demand on the international oil market has made a contribution towards moderating oil and other energy prices.

The Commission believes that, in order to provide a framework for the continuing contribution of nuclear energy to the energy supply, some common principles have to be followed. The suggestions outlined below take account of the balance needed between national and Community responsibilities. They are based on the Euratom Treaty and on the Treaty on the European Union, both of which provide an appropriate framework for the Community to act.

The suggested principles are the following :

- the right to decide to develop or not the peaceful use of nuclear energy belongs to each Member State;

- the choice made in this regard by any of the Member States has to be respected;

- Member States having chosen to use nuclear energy need, in parallel, to ensure a high degree of nuclear safety, respect non-proliferation requirements as provided for in relevant international agreements, as well as a high level of human health protection;

- while it is individual Member States who are responsible for setting safety standards and licensing nuclear installations, and national operators who are responsible for their safe operation, both share the collective responsibility towards all European citizens for ensuring nuclear safety.

If such principles can be the basis of a common approach to these issues, there could be benefits from sharing experience and developing more cooperation.

Such principles, if implemented by the Member States, could also offer the framework for the nuclear industry to continue playing an effective role in the European Union, making a valid contribution to the Union's energy supply and its economic welfare.

A high degree of nuclear safety within the Community alone is not sufficient. Nuclear safety improvements in Central and Eastern Europe and in the New Independent States are also needed, and to achieve this, the combined efforts of the Member States, the European Community, the partner countries and the wider international community are essential.

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ANNEXES

TABLES :

1 - NUCLEAR PROGRAMMES IN THE EUROPEAN UNION[1]

1.1 - Nuclear Power Plants - Installed and planned capacities - Status as of 01.01.1996

	Connected to the Grid		Under Construction	
	N° of Units	GWe	N° of Units	GWe
Belgium	7	5,6	-	-
Finland	4	2,3	-	-
France	56	58,5	4	5,8
Germany	21	22,7	-	-
Netherlands	2	0,5	-	-
Spain	9	7,0	-	-
Sweden	12	10,0	-	-
UK	35	12,9	-	-
EUR 15	146	119,5	4	5,8

1.2 - Natural Uranium Production (tU/year)[2]

	1995	2000	2010
Belgium	40	45	45
France	1016	500	0
Germany	35	0	0
Portugal	18	50	50
Spain	255	810	850

[1] Source - Nuclear Energy Data 1996, NEA/OECD

[2] Metric tonnes of uranium per year

1.3 - Conversion capacities (tU/year)[2]

	1995	2000	2010
France (UF_6) Comurhex / Pierrelatte	14 000	15 500	15 500
UK (UF_6) BNFL / Springfields	6 000	6 000	6 000

1.4 - Enrichment Capacities (10^3 SWU/year)[3]

	1995	2000	2010
France Eurodif	10 800	10 800	10 800
Germany Urenco	3 450	4 000	4 500
NL Urenco			
UK Urenco			

[2] Metric tonnes of uranium per year

[3] Separative work units per year

1.5 - Uranium Fuel Fabrication Capacities (t HM/year)[4]

	1995	2000	2010
Belgium FBFC / Dessel LWR	400	400	400
France FBFC / Romans & Pierrelatte LWR	1150	1150	1150
Germany Siemens / Lingen LWR	950	400	400
Spain ENUSA / Juzbado LWR	220	250	250
Sweden ABB Atom / Vasteras LWR	400	600	600
UK BNFL / Springfields LWR	330	200	200
UK BNFL / Springfields GCR	1590	1550	260

[4] Tonnes of heavy metal per year

1.6 - MOX Fuel Fabrication (t HM/year)[4]

	1995	2000	2010
Belgium Dessel	35	35	70[5]
France Cadarache	15	15	15
France Melox, Marcoule	120	120	120
Germany Hanau	25	120[6]	120
UK Sellafield	8	120[7]	120

1.7 - Reprocessing (t HM/year)[4]

	1995	2000	2010
France Marcoule (Gas Graphite)	400	0	0
France La Hague (LWR)	1 600	1 600	1 600
UK Sellafield (Magnox + AGR)	1 500	1 500	1 500
UK THORP / Sellafield (LWR)	223	633	678

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4 Tonnes of heavy metal per year

5 The additional capacity is in process of licensing

6 Process of licensing has been suspended

7 Start-up : 1997/98

2 - SHARE OF NUCLEAR IN THE ELECTRICITY PRODUCTION (IN %)

	1990[8]	1995[9]	2000[8]
Belgium	60,8	55,5	58,7
Germany	27,8	29,6	26,0
Spain	35,9	34,1	34,2
France	75,5	76,1	76,0
Netherlands	4,9	4,9	4,8
Finland	35,3	29,9	25,2
Sweden	46,7	46,5	47,6
United Kingdom	20,7	24,9	23,4
EUR-15	33,6	34,8	33,1
USA	19,1	19,9	18,6
Japan	25,9	32,2	31,7
Korea (Rep.)	49,1	36,3	37,5
Switzerland	42,6	38,7	38,1

[8] European Energy to 2020 - A Scenario Approach
SEC(95) 2283 of 20.12.1995 - for 2000 : conventional wisdom scenario

[9] Energy - Source EUROSTAT - Provisionnal data (OECD for third countries)

3 - COSTS OF ELECTRICITY PRODUCTION (Ecu/1000kWh)[10]

	Investment	Operation & Maintenance	Fuel	TOTAL
				5 % p.a. discount rate
Nuclear	11 - 22	3,7 - 12	4 - 8	22 - 40
Coal	7 - 15	3,7 - 11	13 - 26	26 - 74
Gas	4,5 - 9	1,8 - 5,2	19 - 42	26 - 56
				10 % p.a. discount rate
Nuclear	19 - 74	4 - 12	4,5 - 7	33 - 60
Coal	15 - 26	7 - 11	13 - 26	33 - 60
Gas	7 - 17	2,2 - 5,2	19 - 38	30 - 60

Assumptions :

1000 MWe PWR commissioning in the year 2000
1991 prices

[10] Projected Costs of Generating Electricity - Update 1992
NEA/OECD, IEA - 1993

4 - LIFETIME LEVELISED NUCLEAR FUEL CYCLE COST (Ecu/1000 kWh)[11]

	Reprocessing option	Direct Disposal option
Uranium	1,22	1,22
Conversion	0,16	0,16
Enrichment	1,38	1,38
Fuel Fabrication	0,74	0,74
Subtotal for front-end	**3,50**	**3,50**
Transport of spent fuel	0,08	
Reprocessing & vitrification	1,235	
Waste disposal	0,015	
Transport/Storage of spent fuel		0,38
Encapsulation/Disposal of spent fuel		0,18
Subtotal for back-end	**1,33**	**0,56**
Credits (U + Pu)	-0,19	
Total cost	4,64	4,06

Assumptions :

1000 MWe PWR commissioning in the year 2000
5 % p.a. discount rate
1991 prices

[11] The Economics of the Nuclear Fuel Cycle
NEA/OECD - 1994

ABBREVIATIONS

ABB	-	Asea Brown Boveri
AGR	-	Advanced Gas Cooled Reactor
BNFL	-	British Nuclear Fuels plc
CEEC	-	Central and Eastern European Countries
CIS	-	Community of Independent States
EPR	-	European Pressurized Water Reactor
FBFC	-	Franco Belge de Fabrication de Combustible
FNR	-	Fast Neutron Reactor
GCR	-	Gas Cooled Reactor
IAEA	-	International Atomic Energy Agency
IEA	-	International Energy Agency
ITER	-	International Thermonuclear Experimental Reactor
LWR	-	Light Water Reactor
MOX	-	Mixed Oxide Fuel
NEA	-	Nuclear Energy Agency
NPT	-	Treaty on the Non-Proliferation of Nuclear Weapons
OECD	-	Organisation for Economic Cooperation and Development
OPEC	-	Organisation of Petroleum Exporting Countries
PINC	-	Illustrative Nuclear Program in the Community
PWR	-	Pressurized Water Reactor
SWU	-	Separative Work Units
THORP	-	Thermal Oxide Reprocessing Plant