Is nuclear electricity the democratic choice of the European Union?

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Abstract:

Electricity consumption is increasing within the European Union (EU) and at the current rate the level of dependency on imported energy resources to meet demand will rise to 70% by 2020 (CEC 2001). During the 1990s assessments of the viability of nuclear generation of electricity were made against a background of lower and more stable energy prices, especially for oil. Governments were able to allow electorates to exercise their choice for a nuclear free energy policy, as cheaper alternatives were available. This is no longer the case. The beginning of the 21st century has been characterised by the rapidly fluctuating prices of alternative energy resources. As costs of energy have risen, the urgency of completing the single market in electricity has become more apparent. For the first time for many years some EU member states are viewing the nuclear option more favourably. Finland has commissioned a new nuclear power plant. Whilst nuclear energy is considered undesirable from the ethical perspective of some consumers, the openness of the European market makes its presence inevitable. As the market for electricity within the European Union becomes more integrated, the choice for those Member States and EU citizens who desire the phase out of the use of the nuclear technologies everywhere is disappearing. The focus is now on the infrastructure to transfer that electricity around the EU. Here is the dilemma, how do you provide nuclear free electricity for those who want it on the transmission lines and electricity grids of the integrated market?

Introduction:

Amongst the more unpalatable realities for the European Union (EU) to swallow is the fact that energy self-sufficiency is not possible, given the present level of development and available technology (cf Tables 1 – 3). As a group of states the EU is becoming more and more dependent on imported energy supplies. This situation will worsen following enlargement and if no measures are taken within the next 20 to 30 years the EU will be 70% dependent on imported supplies of energy. What can be done? It is evident that no one sector alone is capable of meeting the energy requirements of the present or an enlarged European Union. However nuclear generated energy could make a substantially increased contribution and help to overcome the problems of increasing import dependency. As a result the International Atomic Energy Agency has concluded that "....studies suggest that nuclear energy will enjoy a significant share of the total energy production through to 2100 in most scenarios" [1].

At the end of 2001 there were 143 nuclear reactors in the EU of a global total of 438. Between them the EU's reactors have a total net capacity of 123 GWe meeting 35% of the Member States' demand for electricity. The pro-nuclear lobby are arguing that current increased energy prices and an unstable political situation in the EU's main energy suppliers means that the nuclear option should not be abandoned in the short to medium term and indeed should be considered as an essential component of any energy mix in the EU in the future. These arguments are gaining support amongst policy makers within the EU and the national governments. At the same time as support is growing for a more proactive view to be taken of nuclear developments, progress is slowing on commitments, which some national governments of the EU have made, to implement programmes of nuclear phase-out.

It would appear that groups and individuals in society who have expressed their concerns about the continued use of the nuclear option are being misled about the extent to which their views will be addressed. This paper suggests that in those areas where the citizens of the Member States have made a conscious choice to support the scaling down of the industry, the European Union's actions are actually undermining the ability of the citizens to make that choice. There are evident legal,

[1] International Atomic Energy Agency ((2002) "The IAEA, Nuclear Power and Sustainable Development" IAEA, page 3.

economic, environmental and political pressures which will not allow the choice to be made. The single market in electricity only allows for a collective choice to be made. Individual preferences are totally undermined by the pooling of resources.

Two issues underlie the discussion of this paper. Firstly, the implications for contemporary generations of ensuring that there is an equitable and fair allocation of the resource of electricity in a liberalised European single market for energy. Secondly, the justice and equity of leaving potential risks and burdens of waste management and disposal to future generations. There is much public concern and indeed much open opposition to the continued use of nuclear power generated electricity within the EU. The safety of the technology and the management of the waste which result are the main issues which have led to the decisions in some Member States to phase out or completely abandon the nuclear generation of electricity (Table 4). Whilst the European Union does not interfere in the way in which the Member States organise the provision of electricity within the national context, the EU does have many powers and policy measures which have direct consequences on these decisions.

The opportunities for individual choice of electricity generation become very problematic as questions of efficiency and the costs of energy generation come to the fore. When the price of oil rises, and supply of the energy resource is threatened, as it has been in recent times, there is increased support for the nuclear alternative. The long term price of natural gas is rising as global demand expands. Central and Eastern Europeans may consider their reactors to be unsafe and need to be closed, but feel left with no alternative to ensure economic progress and future development. Against this background of growing economic pressure the costs of the nuclear option are appearing less important to the policy makers. Arguments have emerged to support the nuclear option as a means of maintaining low levels of carbon emission and thus meeting the targets set in the Kyoto Protocol. There is a growing lobby of environmentalists who support the nuclear option for this reason (e.g the World Nuclear Association, the Environmentalists for Nuclear Energy).

The Commission's Green Paper "Towards a European Strategy for the security of energy supply", adopted on 29th November 2000, launched a wide-ranging debate on energy provision [2]. The conclusions were

[2] Commission of the European Communities (CEC) (2000) Green Paper "Towards a European Strategy for the security of energy supply" COM (2000) 769

published in June 2002 [3]. On nuclear energy it was clear that for various reasons the nuclear industry was regarded as a **less than perfect energy option (CEC:2002:30)** which may be classed as an **undesirable source of energy in doubt (CEC:2002:30), tainted by the original sin of dual usage in the fuel cycle (CEC:2002:31)**, and as a result may be regarded as **having an uncertain future (CEC:2002:32)**. If these conclusions are correct a whole series of questions are raised which are not being answered.

Amongst these questions for the European Union are:-

- Why is market liberalisation emphasised by the European Commission as the desirable objective but little regard paid to the choices which some citizens have made about the nuclear option?
- Why is the European Commission sending out mixed messages through support for the nuclear option in other policy areas?
- Why is the European Commission proposing that EURATOM loans should be given to help with the building of new reactors in the accession states?
- Why is the European Parliament unable to act to protect the choices which are made by citizens about the nuclear option?

For the national governments other questions may be asked including:-

- Why has the Finnish government agreed to the development of a new nuclear reactor?
- Why is the Finnish prime minister castigating his fellow EU partners for expecting too much from the accession states in the calls made for closure of unsafe reactors?
- Whilst the UK government does not propose new nuclear build, why has the possibility not been ruled out of future new reactors? [4].
- Why is the French government able to continue its support for the nuclear option?
- Why are the five states[5], where agreement has been reached on a moratorium on nuclear power, going slow on the implementation of the measures?
- Why is the Spanish government extending the licenses for capacity at the nuclear reactors?

[3] Commission of the European Communities (2002) Final Report on the Green Paper "Towards a European Strategy for the security of energy supply" COM (2002) 321 final

[4] UK Department of Trade and Industry (2003) "Our energy future, creating a low carbon economy" HMSO Cm576:61

[5] Sweden, Spain, the Netherlands, Germany and Belgium

The answer to all of these questions given in this paper is that despite public concerns about the nuclear sector there is no viable alternative to the nuclear option. Both the EU and the national governments are thus engaged in "sweetening the pill". They are continuing to pay lip service to the concerned portions of the electorate, but are not giving them the full picture with regard to the future of the nuclear generation of electricity.

Dominance of national and sectoral interests in the development of European Union energy policy

The powers of the EU in the area of nuclear energy policy are the result of the complex nature of the Treaties which provide the legal framework for the operation of the European Union. The EURATOM Treaty conferred powers on the community for worker safety, research and market creation in the evolving nuclear industry. There were two main reasons for this. Firstly the importance of finding a secure and readily available supply of energy was a vital element of the economic reconstruction of post war Europe. Secondly the drafters of the EURATOM Treaty felt that they had identified a sector of economic activity in which to pursue the wider objective of European integration without impinging on national interests. However this was an incorrect assumption. National and sectoral interests were present in the sector in the 1950s. Without the current heightened concern about the environment, energy supply in the 1950s was seen as largely a technocratic issue. The actual development of energy was, as it has remained, the subject of the Member States domestic policies. They planned the energy sector, determining the mix and strongly influencing as a result the overall reliance of the EU on imported energy resources. The sector continues to be dominated and undermined by national and sectoral interests today.

The Treaty of the European Economic Community focussed on trade and the development of the Single Market. The European Economic Community Treaty conferred powers on all products, including electricity, being traded in the Single Market. The TEC in identifying the activities of the Community lists "...measures in the spheres of energy, civil protection and tourism..." Art 3 para u and does not use the term 'policy'. National choice of energy resources remains an area of unanimous vote and hence national veto in the Treaty. On the other hand the TEC does contain a specific chapter (Chapter XV, articles 154 to 156) which deals with the development of the Trans-European networks. These are the infrastructural developments which are seen as crucial to

ensure that there is an effective transfer of energy around the EU, and a 'real' internal market put into operation. The area of energy was however left out of the Single European Act and the programme outlined for the introduction of the Single European Market in the mid 1980s. Sleight of hand and careful use of other Treaty provisions promoted the internal energy market in the mid 1980s as the Commission's powers relating to competition policy were used for energy market proposals[6].

As a result of the treaty basis for nuclear electricity development in the EU the possibility for action is wide-ranging (safety of workers, research, market creation measures, controls on movement of hazardous waste in the market, liberalisation of electricity generation) but somewhat ineffective as a contributor to the development of a common policy on nuclear electricity. The dominance of the national and sectoral interests which have contributed to constraints in the nuclear sector are evident throughout the overall energy policy which has developed within the European Union. EU energy policy is neither a common policy nor is it a comprehensive policy. It centres on one primary objective - security of energy supply within the European Union. Three "pillars" of action provide the support to achieve that objective. Firstly measures have been and are being introduced to ensure that there is security of access for the European consumer (both domestic and industrial) to uninterrupted supply of energy products. Secondly that a competitive European market develops so that the energy products are supplied at a price affordable to all consumers. Thirdly that in the development of policy measures environmental concerns and the objectives of sustainable development outlined in the Treaty (Articles 2 and 6 TEU) are respected.

The option for choice of supply is undermined by the liberalisation of the market and the pressures to make electricity available at cheaper prices to the consumers. Environmentalists are offered the argument that nuclear energy will enable objectives of sustainable development to be met within the EU as a means of allaying their concerns. It may be that nuclear energy will allow the Kyoto targets on greenhouse gas emissions to be met but the broader objectives associated with sustainable development are not met by nuclear generation of electricity. National governments are encouraging their electorates to adopt what is considered to be a more pragmatic approach to the issue and enable them to keep the nuclear option as one element to ensure that there is a more balanced energy

[6] The White Paper "Completing the Internal Market" COM (85) 310 did not include the energy sector. Instead a package of draft directives were introduced in 1989 to provide the framework for the development of an integrated energy market. These included in the transparency of pricing for both electricity and gas, less restrictive rules on transit of gas and electricity and monitoring of large investments made in the energy sector.

package available. The nuclear industry itself has been engaged in a continuous programme of information about the introduction of comprehensive safety features and standards.

Development of a cost effective nuclear industry

The nuclear industry has shown that it can produce more electricity during the 1990s as a result of efficiency gains, despite the decommissioning of plants. The shut downs which have been accomplished to date have been mainly of smaller and prototype reactors. Companies have thus been shedding the older and less efficient of their provision and have been able to concentrate production at the newer and more efficient plants. At the same time the operating capacities of the existing plants and their licenses to operate have been extended by the national government licensing authorities. In turn this has contributed to increasing the amounts which the nuclear electricity companies have been able to generate. The next phase, if political agreements are maintained, will include larger and more of the full sized commercial plants. The overall amount of the electricity currently being generated by the nuclear reactors in the EU has increased through the 1990s and into 2002 to its current 35% of energy supply. Despite the concerns of the national electorates of the EU the national governments are realising that the existing alternatives will not match the demand in the foreseeable future, unless the nuclear sector is maintained. Instead they are encouraging the view that, at the very least, no option should be abandoned in the search for national energy provision.

Even some of the oldest plants in the EU have had their operating licenses extended by national authorities in the past in order to meet demand. The oldest commercial nuclear power stations were the Magnox reactors of Calder Hall and Chapel Cross in the UK (cf Table 5). Their operating licenses were increased from 25 to 50 years. This was revised slightly in June 2002 when British Nuclear Fuels (BNFL) announced that Calder Hall, opened in 1956, will close in 2003 rather than 2006, and Chapel Cross, opened in 1959, will close in 2005 rather than 2008, as a result of some technical difficulties at both plants. In Spain 6 of its 9 reactors are being given licenses to upgrade their capacity by 15% by 2003 with increases of operating licences for a further 10 years. So although decommissioning is proceeding at two Spanish reactors the share of nuclear generated electricity continues to grow. Finland in addition to commissioning a new reactor has boosted capacity by 23% at an older plant at Olkiluoto. In Sweden two plants commissioned in 1978 and 1980 respectively had their licenses increased so that they are able to

operate until 2018 and the Swedish Loviisa plant has been authorised to increase its operating capacity by 11%.

The future development of the nuclear industry will be determined by several factors. The active choices which some individuals have made to try to avoid the nuclear option and support the end of any nuclear programme in the EU does not appear in the equation. The cost of alternatives is the most significant. It would appear that the economic imperative will always win. However other issues are gaining prominence on political agendas as a result of public concerns. These include the extent to which the problems of managing and stockpiling nuclear waste are overcome, the viability of the new generations of reactors, and the safety of the central and eastern European reactors. Following the terrorist attacks in the US on September 11th 2001 the security of nuclear installations and the possibilities of terrorists gaining access to nuclear technology has also been added to the list of factors which will govern future nuclear developments (CEC 2002:32).

Concern about the economic implications of closure of the nuclear reactors appears to have governed the approach which governments have taken in the accession states of Central and Eastern Europe. As the negotiations with the accession of Central and Eastern Europe have continued issues of safety of a number of reactors have been raised within the EU. This is particularly true of those based on Soviet designs. Agreement has been reached for the closure of the Bulgarian reactors Kozloduy 1 to 4. But Bulgaria meets 47% of its electricity needs from its nuclear reactors and is already 70% dependent on the import of costly energy resources, especially oil, to meet all its energy needs. The nuclear option will continue to play a crucial role in the Bulgarian energy balance for some time to come. Some of other applicant states have also agreed programmes for the decommissioning and closure of reactors which are considered to be unsafe (e.g the Ignalina plant in Lithuania is timetabled to close by 2004 [7]). Others, including Poland, not currently a nuclear state, do not want to abandon the nuclear option for the future because of concerns about the future development of their national economies (cf

[7] The 2 reactors at the Ignalina plant were causing concern as they are of the Chernobyl type. Reactor 1 was to close by 2004 and reactor 2 by 2009 in the timetable set in the agreement with the EU. Whilst Lithuania is 85% dependent on nuclear electricity the Ignalina plant was built to provide electricity to Belarus during the Soviet era. The state of Belarus has been unable to afford to purchase the electricity produced at Ignalina since 2000 and in fact the first reactor was shut down as a result by 2001 and the second is only functioning at 50% capacity. Disposal of the radioactive waste is an issue still to be resolved. The approach of most countries is to dispose the waste which they have generated. Here is a case of a plant located in one state to serve another within a very different political environment. Neither Lithuania nor Belarus has long term disposal facilities.

Table 6). Some of the states have ongoing developments in place and others may move to commissioning new nuclear reactors in the future. All of the candidate states see opportunities to export electricity in their future membership of the single integrated energy market as a means of enhancing their overall economic development.

Citizens' choice and the liberalisation of the market

The European Union is actively pursuing the liberalisation of the energy market to allow consumers greater choice and opportunities for lowering of prices. This appears as a constantly re-iterated theme in the conclusions of the Presidencies following the summit meetings of the European Council [8]. There are two issues here which are relevant to this discussion, firstly the openness of the market for electricity in the Member States and secondly the degree of interconnectivity between the national electricity markets to allow the development of an integrated European wide market. Both elements are a vital part of the goal of security of energy supply within the EU. The first has been more successful to date than the second but both are considered to be essential if the European market is to operate effectively. Here is the concern – will a fully functioning market mean that the consumer has no possibility of having their concerns about the nuclear generated electricity into account?

An integrated market in electricity within the EU would achieve all the benefits which are seen as part of the effectively functioning European market - lower prices, increased competitiveness, high standards of public service, (and in the case of energy) security of energy supply and environmental protection. Lack of competition as a result of failure to liberalise the market would also result in an inefficient allocation of resources and inefficient price signals being sent out. Some environmental benefits would be the result of this greater efficiency f

[8] "Rapid work is required in order to complete the internal market in certain sectors and to improve under-performance in others in order to ensure the interests of business and the consumers.....The European Council accordingly asks the Commission, the Council and the Member States, each in accordance with their respective powers .....to speed up liberalisation in areas such as gas, electricity , postal services and transport" Lisbon , March 2000.

"....the creation of an effectively functioning internal market in services is one of Europe's highest priorities .....and must go hand in hand with a framework for developing effective cross-border markets supported by an adequate infrastructure capacity" Stockholm, March 2001

"Priority should be given to reaching agreement on the basis of proposals relating to the opening and further development of the energy markets, taking into account the requirement to satisfy consumer needs and the need for transparency....." Barcelona 2002

resource use and allocation. Specifically three benefits are considered to be the outcome of current legislation to create an integrated energy market (CEC 2001):-

- All EU companies would receive the benefits of the increased competition as a result of the opportunities to increase efficiency and lower prices which would enable them to increase their competitiveness and thus help to create employment

- All EU consumers would receive the full benefits of market opening through lower domestic bills for electricity

- A level playing field would be created amongst all the Member States electricity generating companies by opening the market and helping to integrate all the fifteen national markets.

Whilst reference in Commission reports and communications on the single energy market is made to nuclear safety, these references are limited. Public opinion on the phase out of nuclear technology is not an issue addressed within the context of the development of the integrated electricity market by the EU. The economic imperative of the completion of the integrated market is of primary importance. It is the end product - electricity, which is the concern of the EU. Specifically how the product, electricity, may be used within the market and how the service of its provision, at a reasonable price, may be ensured to the consumer. There is no denial in this paper of the importance of the commitment to the right of energy to all consumers, especially the most vulnerable, which the integration and completion of the integrated market is seeking to ensure. That too is an important ethical issue which European policy makers are seeking to ensure. "This universal right to be connected to the electricity grid and to be supplied at a reasonable price must be preserved [9]". The question which remains is about the extent to which it is ethical to deny the anti-nuclear lobby their right to choose the source of the energy which is supplied in the integrated market.

The objective of the EU through the integration of the single market for energy is to ensure competitive prices to the consumers. Competition in the market makes it easier to judge the relative merits of the various energy resources which are available and so the costs of the nuclear option are more transparent. However an accurate view of costs can only

[9] Commission of the European Communities (2002) Final Report on the Green Paper "Towards a European Strategy for the security of energy supply" COM (2002) 321 final

be obtained when issues such as decommissioning of redundant plants or the cost of borrowing to build the nuclear plants (60% of the total generation costs) are included in pricing structures of comparisons (cf Table 7). Other modes of electricity generation carry costs which have to be taken into consideration in the choice of energy mix which a national government makes. The EU is not asking questions about different modes of electricity generation, that is an issue for the national governments to determine. The decision of the national policy makers will revolve around the perceived economic competitiveness of the nuclear plants. Indeed this is likely to be the most important factor determining nuclear generated electricity's share of the European energy market.

The view of the nuclear industry regulators is that as the cost of gas and oil prices rise then the nuclear power stations are becoming more economically viable. Initial costs of commissioning a nuclear plant remain very high and it may take a long period of time before the plant becomes operational but fuel costs are very much lower and the longer term cost advantage evident. This argument was supported in a Finnish study published in mid 2000. In this study the nuclear option was compared to coal, gas turbine, combined cycle and peat and shown to be the least cost alternative to create new generating capacity[10]. It was at capacities of over 64% of operation that the nuclear option began to emerge as the cheapest. Comparison of the proposed new reactor unit in Finland showed figures of 12.8 Finnish pennies per kWh compared with 14.3 for coal and 15.5 for gas [11]. At 90% of capacity, which is the operating practice at the current Finnish nuclear plants, then the costs of the nuclear option fall further and the competitive advantage increases. It was recognised that the nuclear sector has much higher capital costs but lower fuel and operating costs over time. In the case of nuclear energy a significant rise in the basic costs of uranium would have only a minimal impact on the cost of the electricity to the consumer, whereas a minimal rise in the cost of natural gas would have a significant impact on the cost of the electricity.

Liberalisation of the electricity market

The electricity directive was adopted on 19th December 1996 to be entered into force by 19th February 1997. National implementation was to have been completed by 19th February 1999 apart from Belgium and Ireland (19th February 2000) and Greece (19th February 2001). This

[10]WNA (2001) "The long term sustainability of nuclear energy", World Nuclear Association submission on CEC Green Paper on the security of energy supply, 7th November 2001

[11] FORATOM (2001) " Position paper on the Green Paper on Security of Energy Supply" page 4.

directive identified the minimum market opening to be achieved in every state. It did not preclude a Member State offering more market openness than this minimum of 30% of the market by 2000, increasing to 35% in 2003. There were some delays in some of the Member States of the EU and following the Lisbon Summit, revisions [12] were proposed to the directive which are intended to speed the market opening. These proposals are based on increased support for the development of effective market structures and the repeal of directives from the early 1990s [13] to allow transmission systems operators non-discriminatory access to the grid of other transmission operators. A timetable for the opening of the electricity market was proposed by the European Commission in 2001 (CEC 2001b). It was agreed during the Barcelona Summit and again confirmed by the Heads of Government during the Seville Summit in June 2002. Since the electricity Directive was implemented the price of electricity for all industrial and domestic consumers has fallen in most Member States (cf Tables 8, 9). The falls in prices being greater on the whole in those states where the liberalisation process began first and has reached 100% (more than the basic requirement of the Directive).

Cross border trade within the liberalised energy market

Cross border trade ie the physical exchanges of electricity between countries within the EU, remains low at about 8% of total electricity production. (Somewhat paradoxically the EU has undermined this trade itself as a result of the success which the liberalisation of the energy markets has achieved in the cutting of national energy costs). The objective clearly outlined to support the operation of the single energy market and contribute to security of energy supply is to increase the interconnectivity which exists between the national energy markets. The picture across the EU shows, that in comparison with other areas, the European electricity market is increasingly integrated but cross border transfer is being undermined as access to the transmission grids is problematic and there is congestion of the existing grids. Until these two problems are addressed it will be difficult to ensure that market liberalisation proceeds further and increases its effectiveness.

The UK government is in the vanguard of the Member States which are pushing for greater liberalisation of the energy market with increased opportunities for connectivity between the electricity grids of all the

[12] CEC (2001a)

[13] Directives 90/547/EEC and 91/296/EEC on the transit of electricity and natural gas in order to ensure homogeneous and non-discriminatory regimes for transmission including when this involves cross-border transport within the Community"

Member States and effective access to electricity wires[14]. As an important component of energy production in the EU the recommendations of a recent House of Lords report also added that the nuclear option should not be lost and that the EU "... should aim to at least retain its present proportion of nuclear power generation ..." (House of Lords, 2002: para 12, Executive Summary). In addition the House of Lords Select Committee also concluded that there is a certain inconsistency within the UK amongst those who oppose nuclear electricity as there is a significant import of electricity from France which the House of Lords Select Committee considers will have "almost certainly" been generated by nuclear fission technology (House of Lords, 2002:para 79).

It is clear that as the impact of liberalisation is seen in the single integrated European energy market, conditions of competitiveness for the different energy resources will alter. In each of these cases the nuclear option acquires credibility as the provider of secure supplies. Globally, in the long term, prices for natural gas will rise as the demand for the reserves increases. Current political instability in the Middle East will have two effects on the access of the EU to oil resources. Firstly it will undermine security of access to supply. Secondly it will lead to increase of prices as demand for an increasingly limited supply increases. By the end of February 2003 oil prices had risen to over $36 per barrel and it was speculated by the media that $60 could be a possibility in the event of war with Iraq. In contrast nuclear energy costs show evidence of a downward trend.

The capital costs of construction of nuclear plants is falling as designs become more established and there is no longer an imperative to construct each plant on the basis of new science and technology innovation. The industry is able to learn lessons from what is now a long history of experience. Design changes include increasing the size of plants, improving construction, reforming the national regulations which govern plant construction, including those associated with the planning process, reducing the time taken to build a plant, standardising the construction process, construction of multiple units at one site, and replacing older reactors with newer on the same site. If plants are operated at full or close to full capacity, the fixed costs of production are spread over a greater value of output. Taken together these two features mean that the cost of producing nuclear electricity has fallen considerably. Indeed in terms of efficiency in the energy mix it would be more appropriate to have the nuclear plants generating at full capacity

[14] House of Lords (2002) "Energy Supply: How secure are we" Select Committee on the European Union, 14th Report, Session 2001-2002

and use the gas and oil powered stations as an additional source to meet peak demands!

Interconnectivity of grids between areas where nuclear production is predominant (as in France) with areas (such as Germany) where a programme of phase out has been adopted will increase the lack of choice for individuals or groups. This is already apparent in Germany. The closure of the nuclear plants in Germany was only possible because, certainly in the short term, electricity could be imported form elsewhere to make up the shortfall. France is the largest exporter of electricity within the EU with 70% of its electricity coming from the nuclear sector. A significant proportion of the German imports of electricity from France will almost certainly have included electricity generated by nuclear fission technology!! Some of the executives in the German electricity industry have pointed out that the agreement on closure of the nuclear plants was the result of a political decision by the German government in June 2001 and political decisions may easily be changed by another political decision. In their view if an electricity shortage was to occur, which could not be made up in the longer term by imports, then there may be a reversal of the current German nuclear policy.

Increased interconnectivity will affect not only those states which are involved in the export and import of the electricity, but also those states which are in the direct path of the electricity to the consumer. Because of the technology and flow of the electricity itself loops may occur in the transfer of the electricity which brings in neighbouring states not engaged in the direct transfer. "In a simulation, it has been shown that in the case of a transport of 1,000 MW from Northern France only around 60% of the electricity reaches Italy directly by crossing the French - Italian border or through Switzerland. The remainder reaches Italy indirectly causing flows on the networks of Belgium, the Netherlands, Austria and Slovenia" (CEC 2001a:5).

Those who oppose nuclear generation of electricity are currently being 'protected' within the European market by the combination of these two issues. Firstly, there is the question of the lack of interconnectivity of electricity transmission systems within the Member States. Secondly, the congestion of the grids which exists in some areas where there is interconnectivity limiting the import capacity of the Member States. The European electricity market remains segmented with an apparent core area and six satellites with limited import capacity (cf Tables 10,11). There is however clear pressure to remedy these shortfalls which are fragmenting the integration of the energy market.

The European Commission has concluded that "It is clear that existing interconnection is inadequate in many areas of the EU. It is equally clear that this **prevents the completion of the internal market and has a negative impact on security of supply**" (2001c:6). Targets have been set for all Member States for an initial level of electricity interconnectivity of at least 10% of generation capacity to be achieved within a reasonable time. As some Member States have already reached this level, higher targets will be set in specific cases, as will targets for states which are 'transit' states. (The transit states include Belgium, the Netherlands, Denmark, Sweden, Germany, Austria and France). Already networks of the Czech Republic, Hungary, Poland, Slovakia and Slovenia are linked to the EU electricity system[15]. Following accession the objective is to integrate these states quickly to the market. All of these states are producers of nuclear generated electricity or wish to maintain their options open with regard to its future use.

Increased connectivity between the states of the EU, the accession states and also Russia is advocated in the final report on Green Paper on Security of Energy Supply with emphasis being put onto the removal of existing and potential bottlenecks in the infrastructure for electricity transfer. (Russia is to commission five new reactors in order to meet the increasing energy needs of its population cf Table 6.) A commitment is also made in the report to ensuring that the completion and integration of the energy market will not interfere with objectives relating to safety in the nuclear industry. "However, care should be taken to ensure that the development of trade does not in the medium term lead to the placing on the Community market of electricity produced in nuclear power stations whose safety is not guaranteed" (CEC 2002:74). Is the EU able to make this guarantee?

Nuclear industry and safety of its operation

Continued mistrust exists within the EU with regard to the nuclear industry and issues surrounding the safety of its operation. Table 12 shows the results of a longitudinal survey of public opinion carried out between 1986 and 1996 in which an increasing number of respondents indicated that nuclear energy carried with it an unacceptable risk and should be abandoned. More recent EUROBAROMETRE surveys in 1999

[15] Germany has reciprocal bilateral agreements with Switzerland, Poland, and the Czech Republic to trade in electricity, Austria agreements with Switzerland, the Czech Republic, Huangary, Slovenia , Italy with Switzerland and Slovenia. Non nuclear or states of the EU committed to phase out with nuclear states!

[16] and 2002 [17] have concentrated on questions relating to management and disposal of radioactive waste. The results of these surveys indicate that almost eight of ten Europeans are very interested or fairly interested in the ways in which radioactive waste is managed in their own states and seven of ten in other European states. In addition the 2002 Survey showed that 51% of Europeans now feel that is all waste is managed safely then nuclear power should remain an option for electricity production but with a challenge also being given in the recorded responses of those interviewed. A challenge "....to the waste management sector to demonstrate in a convincing way that all waste can be managed safely" [18]. The emphasis here is on **ALL** waste as 46% of Europeans feel that the reason why no high level waste has been disposed of is because there is no safe way to do so.

Here is an opportunity for the EU especially, for the Commission because of the unique nature of the powers given in the EURATOM Treaty. Unlike other international organisations which deal with the nuclear sector (eg the OECD/NEA or the IAEA) the EU is in a position to ensure that any legislation on safety standards which is adopted by the EU is legally imposed within the geographical region of the EU. There are nine areas for EU competence listed in Article 2 of the EURATOM Treaty. These include amongst them the promotion of research, the establishment of uniform safety standards to protect the workers in the industry and the general public and the task of ensuring that nuclear materials are not diverted to other uses (i.e military). These safety issues are carefully monitored and scrutinised through the European Commission and the EURATOM Safety office. However the safety of the installations themselves is the responsibility of the Member States. EURATOM does not posses the nuclear installations. The nuclear Member States of the European Union possess the nuclear installations. The EURATOM Treaty does not mention operational safety of nuclear power plants, radioactive waste storage or the development of disposal facilities - specifically those areas which are of most concern to the general public.

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[16] EUROBAROMETRE question 51a (1999) "Would you say that you are interested, fairly interested or not at all interested in the way in which radioactive waste is managed in (our) country"? Grouping very interested and fairly interested responses together the results were 98% of respondents in Greece, 86% in Sweden and France, 84% in Ireland and Finland and 81% in Luxembourg. Question 51 b (1999) ...."in other countries...."showed a lower response of about 70% but levels of interest remained highest in Greece 86% and Sweden 82%

[17] Similar questions posed in 2002 attracted a response rate which was slightly lower in terms of interest in the national management of radioactive waste but the predominant concern of respondents appeared to be the management of radioactive waste in the accession states of Central and Eastern Europe

[18] EUROBAROMETRE Survey 2002, page 45.

It is in the collective interest for the European Union to be concerned with ensuring greater safety and security standards for the nuclear power stations. Calls have come from the European Parliament to initiate action which would enable this to happen [19]. If unlimited access to electricity from plants which were shown to be unsafe were to be the result of further liberalisation of the market and increased interconnectivity then the basis of the liberalisation process would be undermined. Greater competition in an integrated European market does indeed require that there is a comparable framework in all the Member States which rely on nuclear production, otherwise the level playing field of competition would be undermined. In addition giving greater market opportunities to a product being produced in unsafe conditions would in fact maintain the operation of the unsafe facility rather than encouraging its overhaul or closure.

This again highlights the problem of the economic integration of the European Union's single market in its broadest sense. Paul Kapteyn demonstrated in "The Stateless Market" (1996:66) the way in which the single market revealed "...the true fields of tension and painful dilemma confronting the Member States" ie their fear on one hand of national weaknesses which in his view drove them to create a single market. On the other hand it was the same fear which is keeping them from creating a state to control the market. The citizens of the EU do show confidence in the EU acting to ensure rules covering the processing and safety of radioactive waste [20]. There is an acknowledgement amongst all the Member States of the EU of the importance of ensuring safety at the nuclear installations and the role which the European Commission is able to play. But that role as emphasised by the Heads of Government is the monitoring role on behalf of the EU, there is no commitment to move into other areas which might be considered to impinge on the actions of the national governments. "The European Council undertakes to maintain a high level of nuclear safety in the Union. It stresses the need to monitor the security and safety of nuclear power stations. It calls for regular reports from the Member States' atomic energy experts, who will maintain close contact with the European Commission" (Laeken European Council, December 2001).

[19] Report by Paul Rubig an Austrian MEP to the European Parliament in July 2002 called for safety of nuclear plants to be brought under the jurisdiction of a European authority rather than the current practice of national regulation.

[20] 68% of respondents replied that they would feel reassured if the European Union was to set rules for the processing and safety of radioactive waste - EUROBARMETRE Survey 50.0 January 1999. Range of opinion polled - 87% in Italy to 31% in Ireland.

So if consideration is given to the EU as a protector of safety the citizens must not be misled by what may be done by the EU. There are no common rules for operational plant safety across the EU for various reasons, including those alluded to above – the diversity of the national provision and the nuclear industry, the mistrust of the nuclear states about allowing the non nuclear states involved in the setting of these standards, differing national approaches to regulation (e.g. much more prescriptive in Germany than in the UK) and the failure to address this issue in the EURATOM Treaty. There is also considerable opposition from the nuclear utilities and operators themselves to the introduction of EU safety standards. This is typified by the view of British Nuclear Fuels that "...there would be nothing to be gained from co-ordinating this activity at EU level since the existing infrastructure in each Member State that operates nuclear facilities is subject to robust (national) regulation" [21].

In introducing its proposals for a nuclear safety strategy in November 2002 [22] the Commission identified a number of areas where legislative action is required. In making their proposals the Commission bowed to the inevitable national, political and industrial opposition they faced. The proposals to establish obligations and general principles on safety of nuclear installations during their operation and at the end of their working lives are based on a corpus of minimum standards. The Commission has not however given up the aspiration that these standards may become common standards and control mechanisms in the future.

Decommissioning of plants safely is also an issue where there are limited EU standards or safety indicators to use. Modern nuclear plants include operational safety, decommissioning and waste minimisation and management from their earliest design phases. In some Member States of the EU, eg the UK, the management of these newer plants are required to keep comprehensive operational records by the national regulatory authorities. This requirement was also introduced into Germany in 2002 following the revision of the German Atomic Energy Act. The objective is to ensure that at the time of decommissioning appropriate measures may be taken. Decommissioning of older plants is more problematic as operational records and waste inventories are not complete. Other problems include the fact that many of the early reactors were to some degree experimental and so techniques used to clean one site and decommission a reactor may not be appropriate to others. The technology developed to deal with problems at one site may not be transferable to another.

[21] BNFL (2002) BNFL Comments on Green Paper on Energy Security of Supply, April.
[22] CEC (2002) "Nuclear safety in the European Union" COM (2002) 605

As the reactors have aged within the EU and the accession of the ten states of Central and Eastern Europe has progressed, the concerns and calls for improvement of the safety standards has grown. The operators of the nuclear facilities in the Central and Eastern European states are being exhorted to improve their safety standards in order to meet Western safety standards. But what are these 'Western' safety standards? There is no specific legislation on nuclear installation safety in the EU. There is a non binding acquis of voluntary co-operation between the nuclear operators within the EU. There are pieces of legislation based on those articles which relate to health and safety of workers and the public in the EURATOM Treaty. All the nuclear Member States of the EU and the accession states have ratified the International Convention on Nuclear Safety. There is other EU legislation covering nuclear installations - e g the Environmental Impact Assessment Directive. Taken together this forms the core of nuclear safety regulations in the EU which either represent very similar standards to those of international organisations agreements or have incorporated the international standards into the EU.

In order to resolve some of the questions posed in the context of enlargement a Working Party on Nuclear Safety was set up at the end of 2000 by the Council to assess the safety of the civilian nuclear power plants in the accession states. As a result of the report of this working party a consortium of scientific advisors was formed to develop a Performance Evaluation Guide to use in the safety assessments [23]. The objective of the scientific evaluation was to summarise the current status of nuclear safety in the accession states looking in particular at plant modernisation and safety upgrading. Indicators of performance were then developed on the basis of the relevant EU technical documents, documents from the IAEA and various other documents from the US safety agencies and other international bodies.

Conclusions

Nuclear energy is a substantial contributor to the EU's electricity supply and an important non-fossil source of energy. At present fossil fuels are abundant and relatively cheap. Interest in the development and use of renewable energy is strong. Low cost natural gas is available. **Choice appears possible.** In the EU the share of the energy sector provided by natural gas could increase from 40 to 70% by 2020 and coal consumption from its present share of 37% of EU consumption to 80% by 2020. But this would not be indigenous supply, it would be imported supplies of

[23] ENCONET et al (2001) for the CEC "Nuclear Safety in Central and Eastern Europe" Brussels, April.

both resources. Renewables are not able to provide sufficient low cost electricity to meet the demands. There is increased reliance projected on oil from the Middle East producers as the non-OPEC fields reach their peaks of production in 2020. The Middle East is an area of increasing political instability. The future vulnerability of the EU's supplies of energy cannot be doubted. Taking all these factors into account means that a major shift to non-fossil energy within the EU is unavoidable in the foreseeable future. Thus "...prudence requires OECD members to maintain this (ie the nuclear technology) as a realistic option and to make nuclear energy an integral part of the discussions about sustainable energy policy" (OECD 1998:4). **Choice is not possible.** The role and reliance of the EU on the nuclear option cannot allow the choice for the individual citizen.

The underlying question in this paper centred on the extent to which it may be regarded as ethical of the national governments to allow individuals and groups within society today and in the future to believe that they have a choice. All EU states contain those who oppose the nuclear option for various reasons. However, the search for alternatives to achieve the objectives of EU energy policy have become more urgent, choices are thus not available at present time. This is not precluding future changes as technology advances are made – societal choices may be possible at some date in the future, but both national and EU governments are not telling their electorates the truth if give the impression on the issue of nuclear energy that choice is available now. A truer reflection of the current situation is the somewhat cynical view of the nuclear industry itself in Germany – ie the present administration's response to public pressure was a political decision, which only needs another political decision to alter it. Actions speak louder than words and the slowing of the implementation of closures of nuclear reactors in Germany show the reliance of the country on nuclear generated electricity.

Demise of the nuclear option by default but not as the active choice of the citizens of the EU appeared to be a possibility in the mid 1990s. Discussion of costs of decommissioning raised questions about the economic costs surrounding the building and decommissioning of nuclear plants and the likelihood of substantial interest in new developments appeared to be diminishing. However the nuclear industry did increase its share of the electricity market within the EU during the same period as a result of increased efficiency gains from the newer plants. Decommissioning of old nuclear reactors does not necessarily mean that less electricity is available using the nuclear option.

As the wide ranging nature of the damage done as a result of destruction of Chernobyl became a memory, pragmatism, cheaper energy and environmental concerns (albeit divorced from sustainable development!) have become the core of the debate. This is where the emphasis remains. Safety of the nuclear sector and not no more nuclear has become the focus of attention. The completion of the single market gives some states the opportunity to appear to maintain a moral high ground on the nuclear option for their domestic electorates. Austria has the interconnectivity capacity to import from - Switzerland a nuclear state! Germany was able to agree the programme of closures in the knowledge that electricity from France would be available! Sweden was able to close the Barseback 1 reactor in the knowledge that cheap coal could be imported for its coal fired power stations from Poland.

So what about those who are concerned to maintain their opportunity for choice - switch to gas rather than electricity! Canvas suppliers to find those who give details of how their electricity is generated! Or is there a rather more viable option for those who would like to have a choice about the nuclear option. Firstly acknowledge that there is no alternative. Secondly to concentrate all their efforts to ensuring that concerns about safety at kept at the forefront of debate. Safety at the operating plants as well as of the management and disposal of waste is crucial. The EU has the potential to exercise more control over this as an issue for all citizens of all states who have concerns. The EURATOM Treaty already gives some powers but there is a need for the EP to have more involvement in the decision making. There is a need for acceptance by the national governments that the nature of the technologies being used require increased competences for EU action within the liberalised energy market. The nettle avoided for fifty years has to be grasped!

Thirdly continued research into how safety of waste disposal may be improved has to continue not matter what happens to the closure of the nuclear plants. The waste exists it has to be disposed of safely!!!! If research into the nuclear option is not continued then the expertise and incentive may be lost in an area of technology development which carries with it substantial and significant potential for human and environmental catastrophes. The public is prepared to support measures which will ensure that safe management of radioactive waste is achieved. Eight of ten Europeans believe that the generation producing the waste should be responsible for dealing with it [24]. Unfortunately the technology does not

[24] EUROBAROMETRE (2002:48,6,7)

yet exist to deal with all aspects of radioactive waste. Some waste has a lifetime which will span many generations. Phasing out or not building any more reactors does not mean an end to the nuclear industry.

Sixty three percent of Europeans believe that each European country which produces waste should be responsible for developing its own disposal site for high level radioactive waste. Again there is a nettle to grasp. If all Europeans have access in the integrated market to electricity which is the result of the nuclear technology then should some free- ride by not accepting what is an EU responsibility. Current proposals for regional facilities for the disposal of radioactive waste would be the most appropriate solution in terms of economies of scale and ensuring the security of the facilities. However there is little public support from people for the development of such facilities close to individual's homes.

There is strength of support for nuclear power as a means of curbing greenhouse gas emissions. It is considered to be a least bad solution to the problems of meeting the EU's commitments as it is based on a technology which is already available. The EU does not have to wait for the renewable technologies to be more developed and widely used to make them economic and competitive. The competitiveness of the nuclear option may indeed be enhanced as there is a lower social cost to society than the result of the production of energy from fossil fuels. However, the future role of nuclear electricity will rely on maintaining the high level of safety which is currently apparent and improving it in those areas where concerns have emerged in recent years.

Glossary of terms

BWR Boiling water reactor

Decommissioning
Process whereby a nuclear facility, at the end of its economic life, is taken permanently out of service and the site made available for other purposes.

Fast breeder reactors
Are able to make use of more widely available resource of uranium 238 (about 99% of all uranium). It cannot be used directly to produce energy but it can be combined with uranium 235 in the same reactor core. Uranium 235 produces energy, uranium 238 transforms to plutonium 239 which can then be used as fuel in the reactor. Result is that more fuel is produced than used and resources available for up to 14,000 year.
BUT technologically vulnerable reactors which produce large amounts of plutonium which can also be used for nuclear weapons production.

Fission technology
Current use is based on this form of technology. The molecules of uranium 235 are split and the heat energy which this process produces is used. The energy of one gram of uranium 235 is equivalent to three tons of coal. Sufficient resources of uranium 235 exist for 100 years of use

Fusion technology
Fusing of 2 hydrogen atoms to a single atom of helium. Single gram of fuel can develop the same energy as 45 barrels of oil. Fuel is ordinary seawater and thus virtually infinite. There is little radioactive waste or emissions produced.
BUT needs phenomenally high temperatures which as yet not possible to achieve even with laser technology developments. To date only 10% of the laser power necessary is achievable and this will delay commercial production until middle of the century

High level waste (HLW)
HLW is heat generating waste that has accumulated since nuclear plants began their operations. It represents only 5% of the total waste from the industry but is the most radioactive and as yet no method other than storage has been found to deal with this waste. As the temperature in HLW may rise significantly during storage thie factor makes designing storage or disposal facilities more problematic.

Intermediate level waste (ILW)
Wastes which exceed the upper boundaries for classification as low level waste but where the issue of heating is not present are described in this way. ILW is mainly from the reprocessing of spent fuel rods and the general operations and maintenance of radioactive plants. The main components are metals and organic materials, with smaller quantities of cement, graphite, glass and ceramics. As with HLW no final management strategy has been devised for dealing with much of this ILW.

Low level waste (LLW)
Includes metals, soil, building rubble and organic materials which are lightly contaminated. Metals come mainly from redundant equipment. Organic material mainly from the paper towels, clothing and laboratory equipment which have been used in areas where radioactive materials are used. These areas include hospitals, research establishments as well as in industrial processing.

Very low level waste (VLLW)
Covers wastes with very low levels of radioactivity which come form a variety of sources including hospitals. Normally disposed of with domestic refuse in landfill directly sites or indirectly to landfill following incineration.

kWh
Kilowatt hour

Magnox reactor
An early design of reactor in which magnesium alloy is used as a cladding (eg Calder Hall in UK)

MOX
Mixed oxide fuel made up of 95% uranium and 5% plutonium

PWR Pressurised water reactor - water is used as the moderator or coolant but the pressure is maintained in such a way to ensure that no bulk boiling takes place.

Reprocessing
Removal of the outer casing form around fuel and dissolving of fuel in hot concentrated nitric acid. The uranium, plutonium and waste are then separated out form each other using chemical processes.

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Energy Balance in the EU

Table 1. Total Energy demand 2002 met by

	% of total
Oil	41%
Natural gas	22%
Coal (hard coal, lignite and peat)	16%
Nuclear	15%
Renewables	6%

Table 2. Total Energy demand 2030 met by

	% of total
Oil	38%
Natural gas	29%
Coal (hard coal, lignite and peat)	19%
Nuclear	6%
Renewables	8%*

* note not the 12% target hoped for.

Table 3. Share of electricity generation by fuel in EU in 2000.

	% of total
Nuclear*	35%
Coal (hard coal, lignite and peat)	27%
Natural gas	16%
Renewables	14%
Oil	8%

*note the dominance of the nuclear sector in the generation of electricity in the EU.

Source Tables 1-3 CEC (2001) Green Paper "Towards a European Strategy for the security of energy supply"

Table 4. Nuclear and non –nuclear Member States of the EU.

Nuclear states	Referendum held	Moratorium adopted on commissioning	Non nuclear states	Referendum held
Sweden	1980	*	Portugal	
Spain		*	Ireland	
Netherlands		*	Luxembourg	
Germany		*	Denmark	
Belgium		*	Austria	
UK			Greece	
Finland			Italy	1987
France				
UK				

Source Various

Notes on progress in 2002

- Belgium - political agreement to consider phasing out after 40 years of reactor lifetime to be proposed as a law.
- The Netherlands - legal dispute ongoing between the government and EPZ the operators of the Borssele nuclear plant. EPZ consider that there is no agreement to close the plant in 2003
- Sweden - Barseback 1 reactor, removal of fuel from the reactor underway but demolition of the plant is not scheduled to begin until 2020

Table 5. Number of reactors by Member State.

	Number of reactors	Start of construction	Start of operation
Belgium	7	1969	1974
UK	35	1953	1956
Finland	4 (+1 to be commissioned)	1971	1977
France	59	1968	1973
Netherlands	1	1969	1973
Spain	9	1964	1968
Sweden	11	1966	1972
Germany	19	1965	1968

Source: adapted from CEC (2001)
"Main characteristics of nuclear power plants in the EU and candidate states"
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Table 6. Number of reactors in Central and Eastern Europe and Russia.

	Number of reactors	Reactors being built, September 2001	Reactors on order or planned
Bulgaria	6		
Czech Republic	5	1	
Hungary	4		
Lithuania	2		
Roumania	1	1	
Russia	30	3	5
Slovak Republic	6	2	
Slovenia	1		
Switzerland	5		
Ukraine	13	2	

Source: adapted WNA (2001:appendix)

Table 7. Production costs of electricity generated by different technologies.

	Production costs Per eurocent/KWh	**Generation costs compared to natural gas**	**'Hidden' costs which must be considered**
Coal (imported)	3.29	3%	Increased dependency on imported supplies Increased levels of greenhouse gas emissions
Coal (domestic with subsidies)	4.20	32%	Costs of subsides given by national governments
Gas (combined cycle gas turbines)	3.18	0%	
Nuclear	4.51	42%	Waste management and decommissioning
Wind (with subsidies)	4.46	40%	Costs of subsides by national governments

Source: Adapted from CEC (2002) Final report on Green Paper "Towards a European Strategy for the security of energy supply"

Table 8. Price developments for industrial consumers (excluding VAT and energy taxes) deflated and in national currencies.

	1990 - 1995 % change	1995-1998 % change	1998-2000 % change
100% market opening			
Germany	-14.2	-11.0	-21.1
Finland	-	-13.4	-9.0
Sweden	-	-6.8	-7.0
UK	-15.5	-21.3	-2.6
40-99% market opening			
Denmark	-19.9	12.2	-8.2
Luxembourg	-19.8	-8.4	-8.0
Spain	-15.6	-19.9	-2.4
Less than 40% market opening			
Austria	-	-7.1	-3.4
Belgium	-11.0	-4.7	-1.5
France	-5.0	-10.7	-10.9
Greece	-29.6	-9.7	-2.5
Ireland	-9.5	-4.6	-7.8
Italy	-11.3	-0.1	3.2
The Netherlands	-11.9	-6.5	14.5
Portugal	-15.3	-16.5	-15.6

Source CEC (2001b:18)

Table 9. Price developments for domestic consumers (excluding VAT and energy taxes) deflated and in national currencies

	1990 - 1995 % change	1995-1998 % change	1998-2000 % change
100% market opening			
Germany	3.2	-3.2	-10.1
Finland	-	-1.0	-15.5
Sweden	-	9.1	-15.6
UK	3.3	-15.6	-11.8
40-99% market opening			
Denmark	-24.1	4.5	-2.6
Luxembourg	-10.9	-0.4	-5.5
Spain	3.4	-16.4	-11.9
Less than 40% market opening			
Austria	-	-3.7	-7.7
Belgium	-7.5	-3.3	-4.3
France	-5.0	-7.6	-8.0
Greece	-16.8	-8.4	-11.1
Ireland	-15.0	-16.3	10.3
Italy	22.1	-1.2	-9.9
The Netherlands	-11.2	2.0	-1.3
Portugal	2.4	-5.0	-11.8

Source (2001b:23)

Table 10. Fragmentation in the European Energy Market

Segmented markets - Member State	Import capacity
Core area Germany, France, Belgium, the Netherlands, Luxembourg	
Ireland and Northern Ireland	
Great Britain	3%
Scandinavia/Nordel	4%
The Iberian Peninsula	2%
Italy	7%
Greece	

Table 11. Level of interconnectivity capacity

	Member States
20%	Denmark, Sweden, Austria, Belgium, Finland, the Netherlands
10%	Germany, France
3-7%	Ireland, Greece, Portugal, Italy
3%	Spain, UK

Table 12. Which of the following opinions is closest to your own on nuclear power station development?

	1986	1987	1989	1991	1993	1996
Worthwhile to develop nuclear energy	27	31	28	25	20	16.2
Unacceptable risk - abandon	7	8	6	30	33	41.8
Neither develop nor abandon	55	50	51	34	38	29.6
No answer or don't know	11	11	15	11	9	12.5

Eurobarometre Survey No 46 " Europeans and Energy" February 1997, q.54

Table 13. If all waste is managed safely, nuclear power should remain an option for electricity production in the European Union.

	Strongly agree	Tend to agree	Tend to disagree	Strongly disagree	Average	Don't know
EU 15 average	14.9	35.6	15.1	10.4	2.72	24.0

Eurobarometre Survey No 56.2 "Europeans and Radioactive Waste" April 2002, q 9

Table ? Storage of spent fuel elements in storage ponds of German nuclear power stations, 1997-2000

	1997		1998		1999		2000	
Storage capacity	Number	Weight (tSM)	Number	Weight (tSM)	Number	Weight (tSM)	Number	Weight (tSM)
Licensed overall capacity	20843	6575	21865	6877	21865	6877	22037	6965
Spent fuel and partially burnt fuel 1	6442	2289	7382	2582	8410	2931	9614 2	3278
Free capacity 3	5982	1840	6288	1909	5570	1606	4898	1382
Fuel elements in reactor core 4	6473	1898	6473	1898	6473	1898	6473	1900

Source Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany, (2002:110)

Notes

1. Partially burnt fuel which may be used in the core again
2. In addition 126 fuel elements are stored in transport of transport storage casks waiting for off site transportation
3. Not counting the required space for one core loading nor the locations otherwise used for operational purposes
4. The entire core of the Mulheim-Karlich plant shut down in September 1988 unloaded and stored in the storage pond.