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Policy Brief

No.25
May 2011

Nuclear energy in Europe: What future?

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This brief aims to supply a framework of facts and analysis to the debate on nuclear power in Europe. After outlining the details of the crisis in Japan, it describes the current state of European nuclear safety regulation and the various factors, economic and otherwise, affecting nuclear power in Europe. Finally, it examines the debate on the future of nuclear energy with reference both to European energy policy in general and to particular decisions on energy sources which will need to be made.

Introduction - Nuclear safety and the European energy mix

Japan is experiencing a catastrophe following the earthquake and tsunami of 11 March 2011, which caused major damage to several reactors at the Fukushima nuclear plant. This serious accident, classed at the highest level on the international nuclear event scale (INES), has been characterised by "a major release of radioactive material with considerable effects on health and the environment".

The gravity of the situation in Japan has raised new questions about nuclear safety and the assessment of risks, in Europe and the wider world. Even if Europe's geography and geology is not comparable to that of Japan, its nuclear power plants are exposed to numerous risks, relating to nature (flooding and heatwaves), human factors (terrorist attack, operational error) and technology (degradation over time, technical defects etc.).

A crisis meeting was held in Brussels in March 2011 to examine the potential safety risks associated with nuclear energy in Europe. The Commission was charged with preparing general stress tests for all operational nuclear power plants in Europe, in association with member states, national safety authorities and the industry.

But the questions raised by this new nuclear crisis go beyond the realm of safety, inevitably restarting the debate on the future of this controversial energy source. The different responses were quick to emerge and demonstrate the heterogeneity of national situations in Europe.

The early 21st century seemed to announce a new lease of life for nuclear energy across the world, but the Fukushima catastrophe could well profoundly alter the energy sector. In these circumstances, as the European Union commits itself to a transition to a low-carbon society, a debate is needed on the energy choices to come and the best means of achieving sustainable electricity production in Europe.

1. European nuclear policy: between research and safety

At the beginning: the Euratom Treaty

Energy was at the heart of the European project from the beginning, with the European Coal and Steel Community in 1951, then with the European Atomic Energy Community created by the Euratom Treaty in 1957 in order to put into place a European framework for the development of the nuclear sector.

However, the original provisions of the Euratom Treaty were only partially exploited. The industry and market forces were quickly able to balance supply and demand, reducing the need for centralised European intervention. Today the mission of the Euratom supply agency is more theoretical than real, its role mostly limited to recording the supply contracts negotiated directly by businesses with third-party countries (including Canada, Australia, Kazakhstan and Niger).

The European framework for nuclear safety

Beyond commercial and research activities, European nuclear policy aims to establish a European framework for nuclear safety. In general, European regulations are taken from the various international conventions on nuclear safety developed under the auspices of the International Atomic Energy Agency (IAEA – created within the UN in 1957), to which all member states and the European Atomic Energy Community are party.

The EU's main instruments are limited to determining basic standards and other convergence rules in order to ensure a common minimal level of nuclear safety, without explicit provision for a standard European model. The system is essentially concerned with obliging member states to adopt a legislative and regulatory framework which ensures the existence of national safety measures – such as a system of licenses for nuclear facilities, the establishment of an independent regulatory body, and a system for inspecting and assessing nuclear facilities. Each member state must submit an implementation report by 2014. It is not planned that this document be made public.

The European framework is also intended to facilitate consultation and cooperation within the European Nuclear Safety Regulators' Group (ENSREG, since March 2007). This high-level group brings together national nuclear safety authorities and the European Commission. The European Union also contributes financially to the development of nuclear energy and the promotion of nuclear safety. The framework programme for research and technical development grants € 2.7bn for the Euratom budget over the period 2007-13. Numerous financial instruments are also available, such as loans from the European Investment Bank and the EBRD, and pre-accession funds.

The European system has the merit of establishing a common legal framework and promoting a culture of safety. Despite its minimal nature, it has allowed real progress to be made. Moreover, during membership negotiations the EU was able to exert pressure on certain candidate countries in Central and Eastern Europe to obtain the closure of nuclear reactors judged particularly dangerous, in Lithuania, Slovakia and Bulgaria.

Major features of Euratom

National competence. In accordance with the principle of subsidiarity, recourse to nuclear energy has always been the exclusive prerogative of national sovereignty, guaranteed by the treaties.

Research and development. The use of nuclear energy for civil purposes was still at an exploratory stage when the Euratom Treaty was concluded. This is reflected in the treaty, which focuses on research. In order to promote and spread the scientific and technical knowledge essential to the development of the sector, a Joint Nuclear Research Centre was established within the European Commission in the 1970s, and today includes five research institutes (situated in Belgium, Germany, Italy, the Netherlands and Spain). The major project today is ITER (International Thermonuclear Experimental Reactor), which aims to develop nuclear fusion. Its participants are the EU, Japan, China, India, South Korea, Russia and the United States. According to 2010 budget estimates, the ITER reactor's initial construction costs have gone from € 6bn to € 16bn, of which 45% falls to the EU.

Nuclear safety. The technical and safety difficulties inherent in nuclear energy were taken into account from the start via the establishment of "basic common standards of health protection for the population and workers against dangers resulting from ionising radiation". These involve the implementation by member states of permanent monitoring of radioactivity levels in the environment and of radioactive effluents.

Market. The Euratom Treaty contains several commercially-oriented provisions managed by the European Commission which aim to create an internal market for nuclear products and to encourage industrial cooperation.

Supply. A common policy on the supply of fissile materials was also established. The Euratom supply agency gained an exclusive right to conclude contracts for the supply of ores, raw materials and fissile materials from within and outside the Community.

No real common approach exists for the management and storage of spent fuel and radioactive waste, for which member states are alone responsible. European regulation nonetheless obliges states to establish a system of inspection and advance authorisation for the transfer of waste and spent fuel between countries, as is the case between France and Germany.

In addition there is currently no facility for the permanent storage of highly radioactive waste, unlike lower-level waste (where the radioactivity disappears within a few years or decades) which represents the bulk. Highly radioactive long-term waste, requiring more than 100 000 years before the radioactivity disappears, has been stored for 50 years in temporary facilities.

There are currently plans for a Commission directive to give EU-level legally-binding status to standards adopted within the IAEA for each stage of the management of spent fuel. The planned directive obliges each member state to establish a competent regulatory authority in this area. Management and storage of radioactive waste would still be a responsibility of member states and waste would normally have to be stored in the country where it was produced, except where several states agree to share the use of storage facilities. States would also need to notify the Commission of their national programme within four years, indicating the calendar, the location and details of the construction and management of their permanent storage centres.

For highly radioactive long-term waste, the most appropriate option is considered to be deep geological disposal. Here the most advanced countries are France, Finland and Sweden, each favouring a national solution. This approach of "each to its own waste", has limits at the European scale, in particular because the conditions for a burial site are not easily available in every country. Several countries (Romania, Bulgaria, Slovenia, Lithuania, Poland, Italy, Netherlands) have come together within the European Repository Development Organisation (ERDO) to study the possibility of establishing a shared site for waste management in Eastern Europe.

Management of nuclear crises is essentially a matter for national authorities. Each state has its own crisis-management mechanism, constituting a part of the plans for national emergencies. There is nonetheless a system of alert at European level (ECURIE – European Community Urgent Radiological Information Exchange) through which states may exchange information on crisis situations and measures taken. To improve the coordination of emergency services the EU also established a civil-protection mechanism in 2007. Within the European Commission, the Monitoring and Information Centre (MIC) plays a role of technical support and communication (offers of assistance and resource management) within the framework of a Common Emergency Communication and Information System (CECIS).

Lastly, relating to the issue of civil responsibility in the case of nuclear accident, regimes and limits on damage-reparation guarantees vary from country to country. Member states have nonetheless signed up to a set of basic principles adopted within the IAEA, which focus on the responsibility of the operator and the creation of a public fund going beyond the guarantee made by the operator.

Towards a revision of the European nuclear safety system?

In response to the Japanese nuclear crisis, the EU urgently restarted discussions on the potential need for common action on the issue of nuclear crisis prevention. It was decided to implement stress tests at European level, in order to measure the safety of power plants. EU neighbours with nuclear plants (Switzerland, Russia, Ukraine and Armenia) or plans for them (Turkey, Belarus) are invited to join this simulation exercise.

The harmonised risk-assessment criteria to be used during these tests would need to be determined in consultation with national safety authorities and the companies which build and operate nuclear facilities. The criteria relate to seismicity, flooding, loss of electricity supply, loss of cooling capacity, crisis management, and the combined effect of these problems. Some states and the Commission would also like "human" risks such as terrorism to be taken into account, as well as the age of power plants. The various components of these stress tests should be adopted by mid-2011 and implemented during the following semester.

However, any state can decide not to participate in these voluntary tests, or to use different methods to implement them. The tests will be monitored by each national nuclear safety authority and assessed by the Commission with assistance from ENSREG. No decision has been taken on the consequences of a negative test result. The possibility of technical modifications or plant closures remains a matter for national governments.

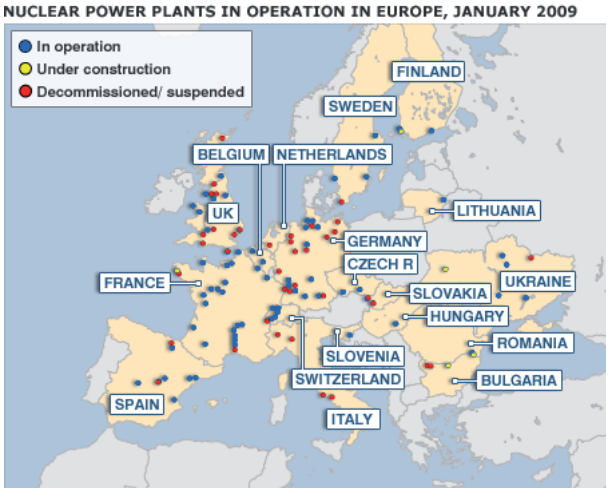
The European Commission is also studying the possibility of proposing a revision to European nuclear-safety regulations, without waiting for the assessment planned in 2014. Essentially this would mean raising the common standards of safety and monitoring procedures, as part of a reassessment of the general risk associated with nuclear energy. One interesting possibility would be to create a European nuclear safety authority, which would allow uniform and transparent monitoring of national systems across the Union. The necessary budget for such an authority could be financed by a specific European tax on electricity from nuclear power plants. In general, dispositions relating to the management and storage of highly radioactive long-term waste, and to transparency and the necessary financial means, could all be strengthened.

The European Union could also make proposals within the IAEA and/or the G20/G8 in favour of stricter safety standards and a strengthening of cooperation, monitoring and intervention capacity at the international level. The current framework only binds state parties to a general commitment to apply certain general safety principles, without detailed standards. Another possibility is to promote an international body to monitor civil nuclear facilities, with genuine powers to investigate and to oblige state parties to correct anomalies found. One means of pressure on governments could be the publication of a "black list" of power plants which do not respect adopted safety standards or recommendations. The regime which covers civil nuclear responsibility and reparations for damage caused by nuclear accidents could also be strengthened.

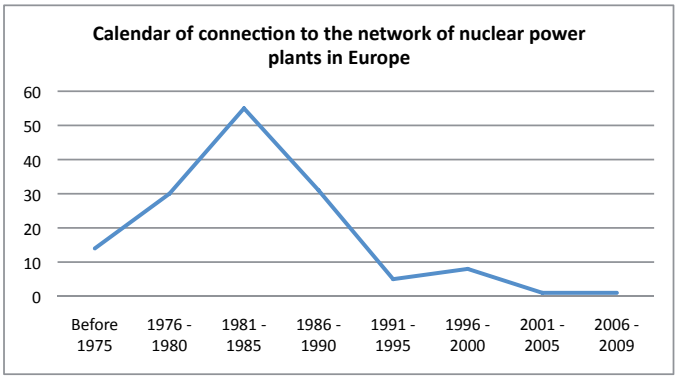
Finally, the debate over revision of the Euratom Treaty could be relaunched, with the aim of convening a new intergovernmental conference which would either adapt the treaty to the new conditions (concerning energy, technology and safety) or repeal it. After member states were unable to agree on a revision of the Euratom Treaty at the intergovernmental conference of 2004, the treaty was integrated into the Lisbon Treaty practically unchanged (protocol 36). The wish of certain states (Germany, Ireland, Hungary, Austria and Sweden) to update the treaty was noted in a declaration attached to the final act.

2. Nuclear energy in Europe: a major reality now in question?

The development of civil nuclear power has been an uneven story. After serious doubts following the accidents at Chernobyl and Three Mile Island, over the last decade the industry has seen something of a resurgence in Europe and across the world. At the international level there exist 437 nuclear reactors, producing nearly 14% of electricity needs, or around 360 GW. Future scenarios generally feature a growing share for nuclear energy in primary demand (6% in 2008 and 8% in 2035, according to World Energy Outlook). The 'Agence pour l'Énergie Nucléaire' (AEN) estimates that there will be a minimum of 600 extra nuclear reactors constructed across the world by 2050, representing a quadrupling of nuclear capacity and a total of 1200 GW. Nearly 40% of this increase will be in China.



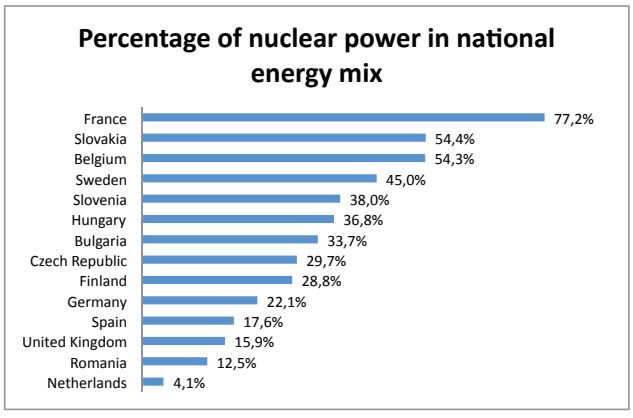
Source: World Nuclear Association (janv 2009)



Source: AIEA

Nuclear power has a major role in today's European energy mix. Europe is the continent with the most nuclear capacity, with 143 reactors in 15 of the EU's 27 countries. According to the European Commission it represents nearly 28% of electricity production, almost the same as coal (29%) and more than gas (23%) and renewables (16%). According to the International Energy Agency, this proportion should fall to 24% in 2030 but in absolute terms nuclear energy production will remain at the level of 2005, due to a major renewal of today's ageing infrastructure.

The peak period for new power plants was the beginning of the 1980s. Nearly 90% of reactors were connected to the network between 1975 and 1985. Most of these plants were initially built with an operational lifespan of 30 years. Without renewal or an extension of their lifespan (potentially from 5 to 30 years depending on the technology used), the number of operational plants could start to fall during the next decade.



Source: Commission - DG TREN

The nuclear landscape within the European Union is one of major national differences. On one side are the pro-nuclear states, with France as leader, producing more than three-quarters of its electricity from the atom. On the other side are states which do not produce nuclear power at all – they include Austria, Cyprus, Denmark, Greece, Ireland, Luxembourg, Malta and Portugal. In between are those countries where the debate over nuclear energy

had been restarted, in particular Germany – where the government decided in 2009 to extend the life of several reactors, thereby reversing a 2002 law mandating an end to nuclear power production by 2020 – and Italy, which decided to reverse a 1987 decision resulting from a massive 80% "no" vote to nuclear power in a referendum. Others in this group include Sweden and the United Kingdom, with major new programmes to renovate power plants, and others – Romania, Estonia, Latvia, Slovakia, Bulgaria, Poland – which had decided to build new plants.

The Japanese nuclear crisis has relaunched the debate on nuclear energy. The United States, India, Russia and China have indicated that they will undertake a full audit of their operational nuclear plants, but currently do not envisage abandoning their nuclear programmes or construction plans. In Europe, several countries immediately called into question their nuclear programmes. Switzerland has decided to suspend indefinitely its authorisation procedures for new nuclear construction and is studying options for ending its use of nuclear power. Germany announced the immediate closure of seven of its oldest reactors (built before 1980) for a period of three months, as well as a moratorium on the law extending the life of several plants by 12 years on average. It also announced a decision to end its nuclear programme in the long term, without specifying a time frame. Italy placed a moratorium on its calendar to restart its nuclear programme, and announced a referendum in June 2011.

Other EU countries have announced that their programmes will continue, while emphasising the need to take lessons from the accident in order to make future plants safer. Poland restated its ambition to build a reactor. France defended its choice of nuclear power, while ordering an audit of its plants. The United Kingdom declared that it was too early to question the future of its planned new plants (four EPR reactors are due to enter service in 2018). Spain announced a review of the security at its six plants and the launch of a study on the risk from earthquakes and flooding. The Czech Republic did not envisage the closure of its two plants but might reconsider the planned new plant negotiated with Russia. Finland simply committed itself to heeding the lessons of Fukushima during the continuing construction of the French EPR at Olkiluoto.

The European nuclear industry

The nuclear industry holds an important position in the European energy market. The industry is dominated by a few "national champions", former state monopolies in which governments continue to hold shareholdings. This is the case of France in particular, but also of Italy and the United Kingdom. However, with the liberalisation of the electricity market launched by the EU in the 1990s, these industrial groups have gradually extended their activities to other European markets. To promote their interests they are grouped within the Forum Atomique Européen (Foratom) in Brussels. In terms of nuclear electricity production, the European and world leader is Électricité de France (EDF), which is present in many European markets as well as the United States and Asia. Other operators include the Germans E.ON and RWE, the Franco-Belgian GDF Suez, the British BNFL and the Italian ENEL. The two leading European industrial groups involved in managing the nuclear cycle upstream (fuel conversion and enrichment, design and construction of reactors, and maintenance) and downstream (recycling and transport of waste, sanitisation and decommissioning of reactors) are France's Areva and Germany's Siemens.

3. The reasons for a European public debate on nuclear energy

The debate over the future of nuclear energy must not be confined to experts, nor to politicians and business leaders. This is a crucial choice for the future of our societies, and it calls for a public debate. The debate must be transparent and enlightened, and it must place in perspective the advantages and risks of nuclear energy in order that every person is able to make an informed opinion. Some of the numerous arguments for and against nuclear energy are summarised in table next page.

Although not entirely comparable, the current Japanese crisis is a reminder of the Chernobyl accident, the worse catastrophe in the history of civil nuclear power (INES level 7). The environmental and human consequences of the explosion at the Soviet plant were terrible: irradiation of people, the release of a radioactive cloud which crossed Europe, the displacement of thousands of people and soil contamination for several decades. Twenty-five years later, no definitive solution has been found for the confinement of the reactor or the decontamination of the surrounding land, of which an exclusion zone extends across a perimeter of 30km. An international donors' conference met in Kiev in April 2011 to work towards a lasting solution and to find the necessary funding, hitherto lacking – including € 800m for the reactor's confinement structure alone. The nuclear industry defends itself by claiming that each past accident has raised awareness of the various major safety risks of nuclear energy, and that this has led to a renewal and strengthening of prevention procedures and a rethinking of power plants in accordance with the demonstrated risks.

The need for a complementary debate at European level

A public debate could well take place within a strictly national context. And yet nuclear energy in Europe inevitably has a transnational and even continental

dimension. A major incident in a member state's plant would inevitably have safety implications for neighbouring countries – especially when near to a border, as is the case for instance of the French Fessenheim plant, near the German and Swiss borders. Countries deciding to avoid nuclear power because of its risks would find themselves indirectly exposed by virtue of the sovereign choices made by a neighbouring state, and their safety would depend directly on the safety policy of that state. Moreover, the current integration of Europe's energy markets and networks is making the option of ending a nuclear programme somewhat artificial, since it will remain possible to import energy from nuclear sources in other countries. This is the case between France, Germany and Austria.

Arguments for and against nuclear energy

FOR – Climate change

Nuclear energy is claimed to offer a major contribution to action against climate change, due to its low emissions of CO2. There is a controversy at European level as to whether nuclear energy should be classified as renewable, a position taken by France amongst others. After several refusals, the European Council of 4 February 2011 (devoted to European energy policy) recognised its status as carbon-neutral energy, alongside renewables. This significant change highlighted nuclear power's come back in recent years.

FOR – Europe's energy independence and security of supply

Even if exhaustible in the long term, uranium resources are plentiful in relation to the current rate of consumption – and by comparison with hydrocarbons, whose reserves are the subject of major tension on world markets, and for which the EU is highly dependent on a few foreign suppliers (around 80% for oil and 60% for gas). In addition, uranium reserves are distributed more evenly and available in large quantities in several politically stable countries (including Canada and Australia). The question of access remains nonetheless important to Europe, since internal production only covers a few percent of consumption.

FOR – Economic competitiveness

The cost structure of nuclear electricity is also said to be an advantage in terms of competitiveness, given the fluctuations in fossil-fuel (gas and coal) markets. The cost of fuel represents only around 10% of production costs, ensuring relative cost stability – unlike classical thermal power plants, where cost is strongly linked to the price of fossil fuels. In addition, the cost per kilowatt-hour (Kwh) of nuclear electricity is said to be less than that from other sources. On the other hand, some point to the major national and European subsidies granted to nuclear power, which makes its cost artificial. Another frequent criticism is that the price of nuclear does not include the costs of plant decommissioning and of long-term waste treatment. Some suggest that these subsidies and other upstream costs should be reinvested in renewable energy and other carbon-neutral technologies in order to reduce their costs and allow their large-scale deployment. Lastly, it is important to note that strengthening safety conditions in nuclear facilities could be costly and have repercussions on the price of nuclear energy.

AGAINST – Safety

The risks to health and the environment are the focus of most opposition to nuclear energy. Even if the risk of major accidents is small ("zero risk does not exist" is a phrase often used), the Japanese crisis has once again illustrated the serious consequences for humans and nature of fusion in a nuclear reactor's core and the release of radioactive particles.

AGAINST – The unresolved issue of long-term waste management

Doubts are also focused on the issue of radioactive waste, of which some elements remain dangerous for over 100 000 years. The requirement for safe and continuous management of storage places over such periods is a clear problem, illustrated by the difficulties experienced at the German storage site of Asse.

For all these reasons, it would be artificial to limit this debate to national confines. On the contrary, it is both opportune and necessary that the discussion take place at European level. However, currently there exists no instrument which would allow for such a debate. One possibility would be for member states to organise separate national debates which would take place in the same conditions and at the same time – as is already the case for the stress tests. An intermediate solution would be regional: neighbouring states belonging to a shared region could organise collective debates (for example France, Germany and Benelux; the Nordic and Baltic countries; the Iberian region; the Višegrad countries; or South-Eastern Europe).

One final option for encouraging a European public debate could be the "European citizens' initiative" established by the Lisbon Treaty. In concrete terms, a petition containing at least one million signatures coming from a significant number of countries would oblige the Commission to examine this specific issue and the possibility of presenting proposals within the EU's areas of competence.

4. What energy mix for European countries by 2050?

On the future of nuclear energy, states can choose between numerous options – from the immediate ending of nuclear programmes to the construction of new plants, or even a gradual winding down which ensures a smooth transition to other energy forms.

Given the major role of nuclear in European energy production, any discussion of a reduction of its share in the mix (possibly to zero) makes it necessary to consider alternatives and replacement scenarios. This debate takes place within the context of European energy policy and in particular the imperative of ensuring a transition to sustainable, carbon-free energy, an EU commitment since 2005.

In concrete terms the EU has set three objectives to be achieved by 2020: a 20% reduction in greenhouse gas emissions relative to 1990 levels; a 20% share of electricity production to come from renewable sources; and a 20% reduction in energy consumption. The EU is today pushing hard to meet these objectives on time and to adapt its energy system to the new circumstances. It has experienced recurrent difficulties in its efforts to establish a common energy policy (see the *Notre Europe* study "Towards a European Energy Community", based on a proposition by Jacques Delors).

The major decisions that must be taken in these crucial fields commit states and industries over decades and therefore require long-term planning. For example, the lifespan of a nuclear, coal or gas power plant is at least 30 to 40 years. Predictability is also indispensable to the energy industry, allowing it to plan large-scale investments and to obtain complex administrative authorisations.

In March 2011 the European Commission proposed a "Road Map 2050" as a long-term European strategy for this transition to a low-carbon economy. This communication proposes to stage the ambitious and necessary climate objectives, with a reduction of 25% by 2020, 40%-60% by 2030-40 and 80%-95% by 2050. The Commission envisages that energy production alone must support a reduction of 93-99% to become carbon-neutral. Nuclear energy features among the low-carbon technologies alongside renewables. As an extension of this "Road Map 2050", the Commission expects to publish a specific road map for the energy sector, which details the options and various means of achieving the objective. The central issue is the future choice of energy sources.

In these circumstances the transition to a low-carbon society requires above all a diversification of the European energy mix, with both stimulation for clean, sustainable energy sources and research into new carbon-neutral technologies. It will be necessary to examine the role of each energy type (renewables, gas, coal, nuclear, etc.), its potential, its advantages and its disadvantages, on the basis of rigorous and independent analysis. In this regard the work undertaken by the International Energy Agency constitutes a good starting point. The EU has an interest in obtaining its own capacities of analysis and expertise in this field, something for which the Commission could take responsibility.

It is already possible to outline several scenarios. Stakeholders, governments, energy producers, NGOs and other interest groups will each argue for the promotion of one or another energy source to the detriment of the others. In an increasingly popular scenario a large share of energy becomes renewable, with some even arguing for exclusively-renewable electricity production. Next come the various fossil energies, for which many scenarios see a complementary, transitional role (more or less large). Lastly, the difficult choice of optimal energy source is complicated by continuing uncertainty over technologies which may affect the sustainability, competitiveness or safety of the respective source. This is the case for nuclear energy (fourth generation reactors), gas (the potential of non-conventional sources such as shale gas), coal (CO2 capture and storage) and renewables (the potential of certain technologies to reduce development and production costs).

Conclusion – Before and after Fukushima

Fukushima will doubtless mark a turning point. The European response was quick, and reflected divergent national situations and the uneven geographic and geological distribution of resources, as well as different national cultures and sensibilities. The debate over the future of nuclear energy has been relaunched, and its outcome is uncertain.

The European Union faces major challenges. On one hand it is asked to learn the lessons of the Japanese disaster so as to avoid such an accident in Europe. In the light of the reassessment of the various risks of nuclear power, the EU needs to strengthen its regulations on nuclear safety – without excluding a possible revision of the Euratom Treaty. In parallel the Union will need to coordinate member states' crisis simulation exercises so as to test the safety level of Europe's operational nuclear plants. That will also mean finding a common response to the possibility of a negative stress test result in a member state. At the international level the Union could make propositions aiming at strengthening existing safety mechanisms within the framework of the IAEA.

The questions raised by this new nuclear crisis go beyond safety and affect the general future of this con-

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troversial energy source. The crisis offers the EU and its member states an opportunity to reconsider thoroughly which energies should be developed and encouraged in order to find an optimal solution in terms of sustainability, safety and competitiveness.

The European Union faces a complex and crucial choice which will represent a commitment over decades and generations to come. For reasons mentioned above, it would be artificial to confine this debate to individual member states. It is rather necessary and opportune for this discussion on the future of nuclear energy to take place at the European level, in the framework of the emerging European energy policy ■

Policy Brief Notre Europe
2011/no.25

With the support of the European Commission
Education and Culture DG
'Europe for Citizens' Programme

design : *Notre Europe*
ISSN 2103-8635