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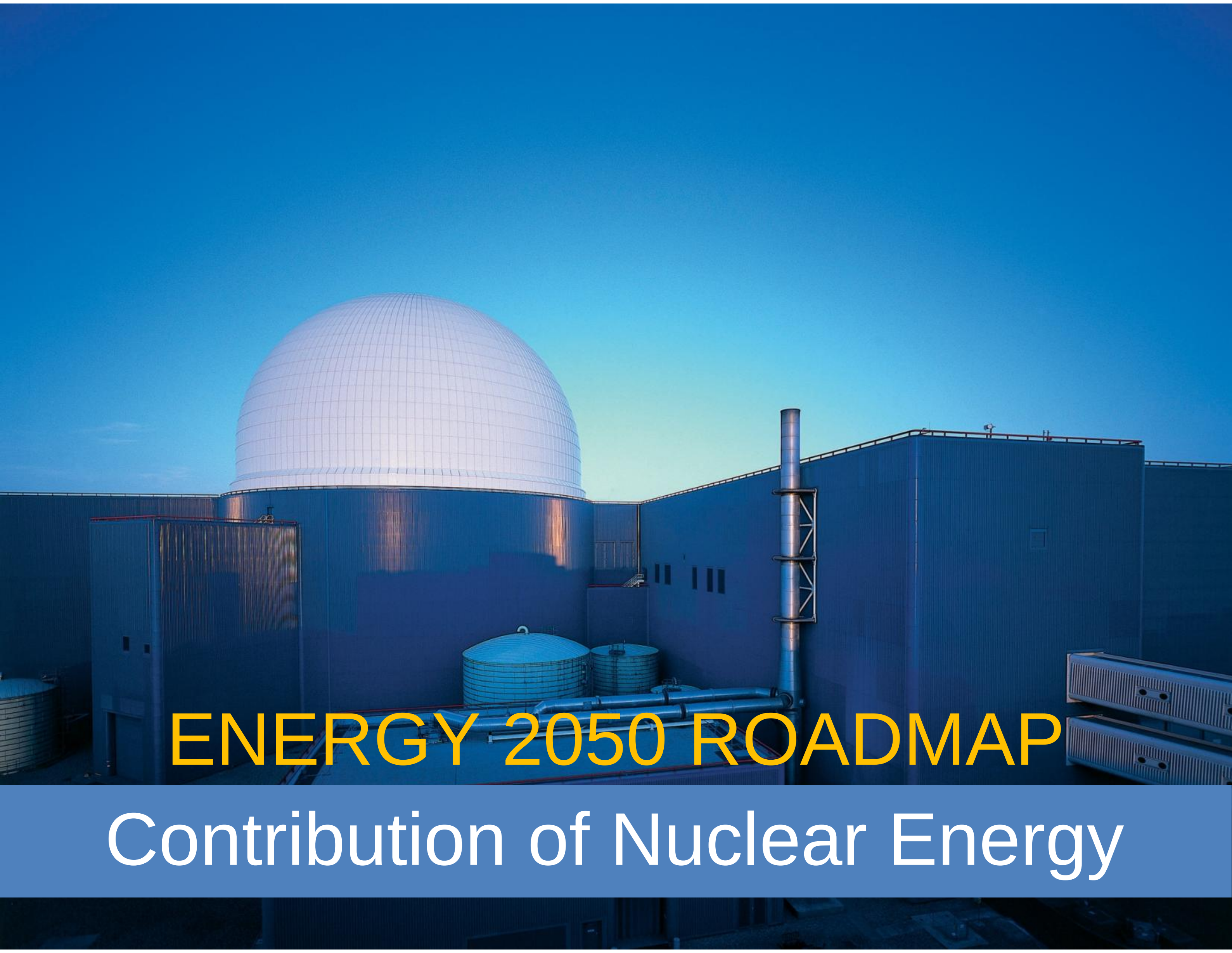

ENERGY 2050 ROADMAP

Contribution of Nuclear Energy

Post Fukushima Update

October 2011

The European Atomic Forum (FORATOM) is the Brussels-based trade association for the nuclear energy industry in Europe. Its main purpose is to promote the use of nuclear energy in Europe by representing the interests of this important and multi-faceted industrial sector.

The membership of FORATOM is made up of 17 national nuclear associations active across Europe and the nearly 800 firms that they represent.

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Introduction

In February 2011, FORATOM published its contribution to the European Commission's 2050 Energy Roadmap Consultation in the form of a 60-page report with the title "Energy 2050 Roadmap – Contribution of Nuclear Energy". The report comprised a review by the Swiss Paul Scherrer Institute (PSI) of existing major energy scenarios, accompanied by a FORATOM analysis of the main drivers and conditions necessary to maintain the current, roughly 30% share of nuclear electricity (14% of primary energy) in the EU through to 2050. The conclusion of PSI was that this nuclear share was compatible with ambitious climate change and electrification objectives.

On 11 March 2011, the Fukushima nuclear accident occurred in Japan with significant consequences for the local population and widespread impact on the media, public opinion and political thinking worldwide. In the aftermath, Germany decided to speed up its withdrawal from nuclear power, Switzerland not to build any new reactors and Italy not to return to nuclear power for the foreseeable future; many other countries on the other hand confirmed that they would maintain their existing nuclear strategies. Following a joint initiative of the European Commission, national nuclear safety regulators and industry, a process of re-assessment of the ability of EU nuclear installations to withstand the types of initiating event (earthquake, flood, loss of electrical power, etc.) experienced in Japan is being undertaken. Some preliminary results of these reassessments are already available and the final regulator reports will be published soon, after which the public will have the opportunity to form a view as to the capability of nuclear plants in the EU to cope with a set of extreme beyond-design-basis conditions, and the effectiveness of existing or newly-proposed preventive measures.

The longer term consequences of Fukushima for nuclear power, i.e. to 2050, are impossible to predict; international organisations are however generally anticipating a slower global increase in nuclear power output than they were in 2010, although growth is still projected to be rapid in Russia, China, India, South-East Asia, South America and the Middle East.

Even though 2050 is still nearly 40 years away, which is a very long time for politico-economic forecasts, it is clear that Fukushima could have a lasting effect on energy policy in some countries. For this reason, FORATOM has committed to issuing the present update.

Global energy context and the need for decarbonisation

The world's population is projected to increase to 9.2 billion by 2050 from the current 7 billion. Most of the increase will be in developing countries. More than 1.4 billion people, mainly in Sub-Saharan Africa and South Asia, still do not have access to electricity. Increasing prosperity in the developing world and the desire to eliminate energy poverty will lead to burgeoning global demand for energy. The World Energy Council predicts that global demand – for electricity as well as energy as a whole - will double by 2050. Fossil fuel substitution will inevitably accelerate continuously growing electricity demand in spite of energy efficiency gains. Wider access to electricity will be coupled with higher expectations for supply security, meaning that electricity will increase in popularity as fossil fuel reserves diminish and become more contested.

Unless there is a dramatic shift away from fossil fuels to low-carbon alternatives, the growth in energy demand will result in global warming becoming the most complex and challenging problem mankind has ever created. The International Energy Agency issued a stark warning in May 2011, that the unexpectedly large increase in carbon emissions in 2010 had put the chances of keeping global temperature rises below the critical 2°C threshold almost out of reach. Pressure on emissions will come mainly from the increased use of coal for electricity generation in the developing world, especially in China, and from greater oil consumption in the transport sector as higher prosperity leads to increased mobility. The chances of the widespread introduction of carbon capture and sequestration (CCS) look remote, when even in the developed world the challenges associated with its large scale application remain substantial.

The European Union wants to continue to lead the world on a path to sustainable development and is committed to decarbonising its economy. It has set a target of an economy-wide 80-95% reduction in greenhouse gas emissions below 1990 levels by 2050. It is generally accepted that this translates into a need to almost completely decarbonise the electricity generation sector over the next 40 years. Given doubts about CCS, this huge challenge can only be met realistically by switching massively from fossil fuels to renewables and nuclear power. **With nuclear power currently providing around two-thirds of the EU's low-carbon electricity, any decision to move away from nuclear power (as we have seen in Germany) only increases the generation gap that renewables with backup have to fill.**

After electricity generation, the next largest contributor to carbon emissions is transport. Efforts to reduce emissions focus on the development of biofuels and electrically-powered vehicles. In its 2010 Power Choices scenario, EURELECTRIC predicts that the latter development will drive a large increase in overall EU electrification, from 20% in 2005 to 45% in 2050. This in turn results in a 72% increase in EU electricity demand by 2050 (annual cumulative increase of 1.4%).

Impact of Fukushima accident

The earthquake and resulting tsunami occurring off the coast of Japan on 11 March 2011 led to enormous devastation of the region North-East of Tokyo and caused the unfortunate deaths of some 20,000 people. The consequent loss of power at the nearby Fukushima Daiichi nuclear power plant caused a fuel melt in three of the six reactors at the site resulting in a significant release of radioactivity to the surrounding area. Unlike at Chernobyl, there weren't any immediate casualties linked to radiation, although the longer-term health effects have yet to be properly evaluated. There was however a massive reaction in the world's media. The public were understandably concerned about the risks of a similar accident occurring in other nuclear power plants around the world, which is why the European Commission, the industry, the national nuclear safety regulators and public institutions in nuclear countries have undertaken to carry out a comprehensive re-assessment of the safety of nuclear installations (focussing on earthquake and flood resistance, loss of off-site power supplies, loss of ultimate heat sink, and emergency response) and to make the results publicly available. The industry has committed to carrying out the required safety checks, reporting to the safety regulators and to implementing any resulting safety improvements. The lessons from Fukushima will be learned and acted upon.

In the EU, the nuclear safety regulators of the 14 countries operating nuclear power plants were required to submit interim reports to the European Commission by 15 September 2011. The Commission is currently in the process of evaluating these interim reports and is expected to present the conclusions to the European Council on 9 December 2011. In the meantime, many of the national reports have been made public. In presenting his final summary report on 11 October 2011, the UK Chief Inspector of Nuclear Installations Mike Weightman said, "I remain confident that our UK nuclear facilities have no fundamental safety weaknesses. The Office for Nuclear Regulation already requires protection of nuclear sites against the worst-case scenarios that are predictable for the UK. But we are not complacent. Our philosophy is one of continuous improvement. No matter how high our standards, the quest for improvement must never stop. We will ensure lessons are learned from Fukushima. Action has already been taken in many cases, with work under way to further enhance safety at UK sites. While it is only six months since the earthquake and tsunami hit Japan, I am satisfied we are in a position to have drawn reliable conclusions and identified the main lessons to improve safety. Detailed technical information will no doubt continue to emerge and the Office for Nuclear Regulation will continue to monitor it and take action as necessary. "

Whilst one should not prejudge the final outcome, it does seem unlikely from announcements made so far that there will need to be closures of nuclear power plants in the EU on technical safety grounds. Any additional safety measures that are required, such as the provision of additional flood protection or emergency power supplies, are not likely to entail additional costs that would render the continued operation of the power plants uneconomic. New NPPs (Generation III+), such as the reactors currently under construction in Finland and France, are designed to provide additional protection against potential accidents and are considered to be very robust.

In spite of the above, a political decision was taken in Germany to close immediately eight of the older operating NPPs and to shut down the remaining eleven plants by 2022, fourteen years earlier than previously announced. The Swiss Government announced that it would cancel plans to build three new NPPs. In Italy, a scheduled referendum to decide whether or not to restart its nuclear power programme was affected both by Fukushima and national politics and resulted in a 90% rejection. Other EU Member States on the other hand, including the other 13 countries operating NPPs, have not changed their nuclear policies. Plans for new nuclear build are reviewed in the next chapter.

Overall we can say that whilst Fukushima has led to temporarily decreased public confidence in some countries and probably to extra short-term costs and some delays in nuclear new build programmes, none of these factors is considered to be decisive in terms of the nuclear contribution in 2050. Provided that public confidence in the nuclear industry's ability to operate nuclear reactors safely can be restored, as it must be – and the industry will play its part - the inescapable benefits of nuclear power are expected to prevail when it comes to future energy choices.

Review of EU plans for nuclear new build post Fukushima

"There hasn't been a strong debate after Japan (nuclear accident) that we should change our decision. I think Finns are very rational, pragmatic. We expect that in the existing plans, the security level is high. And also, on those which are under process, they will be. Security is an important factor but I'm not worried," Finnish Economy Affairs Minister, Jyri Häkämies, on 2 September 2011 (source: Reuters)

"Of course it's time to review and analyse [safety] carefully but it wouldn't be right to make a rash decision, a 180 degree turn. Poland is not at risk of earthquakes and tsunamis. The problem in Japan was not the power plants themselves, but the earthquake. We need to make a decision based on rational analysis and not emotions." Polish Treasury minister Aleksander Grad on 5 April 2011 (source: The Guardian)

"Nuclear energy has risks, but we face the greater risk of accelerating climate change if we do not embark on another generation of nuclear power. Time is running out. Nuclear can be a vital and affordable means of providing low carbon electricity," Chris Huhne, British Climate Change Secretary, speaking at the Royal Society on 13 October 2011 (source: The Guardian)

Reactions among EU Member States in the Fukushima aftermath have been diverse. However, they tend to reflect the traditional positions of the Member States towards nuclear energy as such. The following is a brief summary of recent announcements.

Bulgaria continues to consider nuclear energy as the pillar of its strategy to secure the country's energy needs. The completion of the Belene nuclear power plant after 2015 remains a priority and the government goes on with plans to build two new nuclear blocks.

The Czech Republic wants to preserve its position as a leading electricity exporter in the Central European region. An expected lack of electricity in the region and an approaching phase out of high-CO_2-emitting sources is prompting the Czech government and its dominant utility CEZ to speed up the process of completion of two new blocks at the Temelin nuclear power plant. New block construction momentum is then planned to be maintained by building at least one more block at the Dukovany nuclear plant. The currently discussed Czech energy policy targets a nuclear electricity share of 80% by 2060.

Finland besides proceeding with building its first Gen III+ reactor at Olkiluoto has been after the Fukushima accident the first EU Member State to announce a site for a new nuclear project. The consortium Fennovoima has chosen to build Finland's third nuclear power plant in the municipality of Pyhäjoki. In addition there are accepted plans to construct a fourth block at the Olkiluoto power plant.

France is constructing its first reactor of Gen III+ at Flamanville. A second reactor of the latest generation is to be built at Penly with the planned project start in 2012. France, as the leading nuclear country, is expected to continue gradually replacing its older reactors with new ones of the latest available generation while reconsidering its national energy mix. FORATOM believes that the nuclear share is very likely to stay well above 50% of electricity for the foreseeable future.

Hungary is determined to stay a country banking upon nuclear as the pillar of its energy security. The Parliament already approved plans for doubling the existing capacity of the Paks nuclear plant by 2025.

Lithuania has selected a strategic investor for the Visaginas nuclear plant which is intended to be a major project securing the energy needs of the Baltic region. The Lithuanian government has also already formally notified the European Commission of plans to construct the plant. The project will be developed jointly with Estonia, Latvia and Poland.

The Netherlands have reaffirmed steps they have taken towards construction of a new nuclear power plant at Borssele.

Poland has reconfirmed its plans to embrace nuclear energy and has completed the legal framework for starting construction of new nuclear plants with around 6000 MW of installed capacity.

Romania reconfirmed that it considers its national energy priority is to complete units 3&4 at Cernavoda nuclear power plant.

Slovakia is well advanced in the process of completion of units 3&4 at the Mochovce plant. Furthermore a feasibility study for constructing a fifth reactor at the Bohunice plant is under preparation.

Slovenia is considering parliamentary approval of an application for a permit to build a Gen III+ reactor which will replace the existing capacity of Krsko nuclear plant.

Sweden and its Parliament reversed the phase out policy in June 2010. The country sticks to its plans for replacing the current existing capacity with new reactors.

United Kingdom has announced recently (June 2011) 8 sites it has selected for at least 10 new power plants as a way of meeting the country's future energy demands and its climate goals. In parallel a major overhaul of the legal framework is under finalisation in order to secure investments into carbon free energy sources.

Croatia (not yet an EU member) is considering building its own new nuclear plant and will continue operating its co-owned plant in Slovenia.

Germany has adopted a policy of complete nuclear phase out by 2022.

Belgium *and Spain* have plans neither for new builds nor for replacing existing nuclear capacity, as this theme is in both countries highly politically charged.

Italy held a referendum in the aftermath of Fukushima and voted substantially not to return to nuclear power, overturning governing coalition plans for nuclear to provide 25% of Italy's electricity by 2030.

In summary, the above announcements indicate that 13 EU Member States (14 with Croatia) consider nuclear power to be a key component of their national energy mix and will still be operating nuclear power plants in 2050. Many of these countries will not find it economically or operationally attractive to install large amounts of renewable energy and, even if CCS becomes commercially available, will continue to opt for nuclear power. The actual share of nuclear energy in 2050 is impossible to predict. However, totalling all the new build plans already announced and restated since Fukushima and assuming a 60 year operating life for existing reactors, one can expect a nuclear fleet in 2050 of at least 85 reactors producing 110 GW (equivalent to 20% of predicted electricity demand in 2050). The FORATOM 2050 Energy Roadmap Report published in February 2011 concluded that a range of 160-170 GW (30% of electricity demand) was more realistic, given continuing political support and strong emphasis on climate policies.

Nuclear – a key component of EU energy policy

The FORATOM 2050 Energy Roadmap report published in February 2011 identified a number of key attributes, or "drivers" for nuclear power, which can influence energy policy choices. These drivers remain just as valid now and can be restated briefly as follows:

- **Security of supply** With its 90%+ availability and diversified fuel suppliers, nuclear is a significant contributor to energy security and diversity. It provides security against interruption of fossil fuel supplies or price hikes and offers reliable baseload electricity as a complement to intermittent renewables.
- **Competitiveness** The price of nuclear electricity is competitive and predictable; in most situations, nuclear is as cheap or cheaper than any of the alternatives. The expected increase in CO_2 prices will make nuclear even more competitive.
- **Low-carbon** Carbon emissions from the whole nuclear lifecycle are very low, very substantially below the levels for fossil fuels and comparable with those from the best renewables. Nuclear currently provides two-thirds of the EU's low-carbon electricity and avoids the emission of around 600 Mt of CO_2 in the EU annually.
- **Jobs** The nuclear industry employs around 400,000 people in Europe. The level of qualifications, skills and training required is higher than for other energy industries and contributes to local and national prosperity.
- **Global growth potential** Nuclear power is set to expand rapidly in other parts of the world – Russia, South-East Asia, Middle East, South America. This provides a major export market opportunity for the European nuclear industry.
- **Other applications** Nuclear is a potential low-carbon substitute for fossil-fuel-based combined heat and power production for both domestic and industrial applications such as hydrogen production, oil refining, synthetic fuel production, desalination, etc.

At the same time, a number of "conditions" were identified that need to be satisfied if nuclear power is to maintain its EU energy contribution for the longer term. These are still valid as follows:

- **Nuclear safety** It goes without saying, especially after Fukushima, that nuclear power plants have to be designed and operated at the highest level of safety at all times.
- **Radioactive waste management** The relatively small volumes of final radioactive waste are in general very well managed and safely stored pending disposal. We

need to make progress towards the geological disposal of high-level waste and to demonstrate that the costs of decommissioning and waste management are fully accounted for.

- **Public acceptance and involvement** Open discussion of the pros and cons of nuclear energy and public involvement in decision-making are essential for proper governance and informed choices, as has been demonstrated for example during the selection of waste disposal sites in Sweden and Finland.
- **Political support** Views amongst the EU Member States are strongly polarised and tend to mirror public opinion. As recent events in Germany and elsewhere have shown, nuclear can only prosper with firm government backing.
- **Financing of nuclear new build** The current economic situation and investment environment is not conducive to any large investments but ageing energy infrastructure has to be renewed if the lights are to remain on. Nuclear provides long-term financial advantages provided that a stable and predictable investment environment can be guaranteed.
- **Licensing harmonisation** Standardisation of design approval procedures will reduce costs and enhance safety.
- **Uranium supply** Resources are sufficient for over 100 years at current rates of consumption but further research could lead to significant savings. Uranium prospecting will follow market trends.
- **Supply chain** No supply chain problems are foreseen in Europe with current new build plans, although the provision of large components has suffered from a lack of orders in recent decades. There is a risk that foreign competition will strengthen as the market develops outside Europe.
- **Knowledge management** An adequate supply of well-trained recruits has to be secured, especially as large numbers of older people in the industry retire. There are promising signs that young engineers and scientists once again see a positive future for the industry.
- **Environmental impact and information** Environmental legislation requires the industry to provide the public with access to environmental information. The practical implementation of this legislation needs to be ensured.
- **Nuclear transport** Free movement of nuclear materials is essential to the operation of a nuclear power plant. The excellent safety and security record, underpinned by harmonised international regulations, needs to be maintained and appreciated by the public.
- **Nuclear non-proliferation and security** Industry can have an active role in promoting the responsible use of nuclear energy in aspiring countries, but must continue to ensure compliance, maintain proper control over sensitive materials and technology, deliver effective training and promote the appropriate security culture.

Conclusions

The benefits of nuclear energy in terms of climate change, security of supply and competitiveness make a compelling case for its contributing significantly to Europe's future energy supplies. The nuclear industry fully recognises that this can only be achieved by applying the highest safety standards, by providing for and managing waste safely, and by operating in a transparent way with the support of governments and the acceptance of the public.

The Fukushima accident has shaken confidence in the safety of nuclear power plants worldwide. Completion and open publication of the results of the safety reassessments currently underway in Europe and elsewhere should help convince the public that nuclear power plants here are adequately protected against extreme conditions and that appropriate accident prevention measures are in place. The industry will implement recommendations in this respect coming from the safety regulators. Fukushima is likely to have some effect on costs and new build timescales in the shorter-term but not to be a decisive factor affecting the longer term contribution of nuclear energy.

Current new build plans announced and confirmed by Member States since Fukushima imply that nuclear energy will represent at least 20% of the EU's electricity in 2050. Beyond that, FORATOM's belief remains that nuclear energy can, should and will continue to provide more like 30% of the EU's electricity in 2050 (~15% of primary energy), allowing for the expected substantial increase in electricity demand.

Annex - Key recommendations

The February 2011 FORATOM 2050 Energy Roadmap report (www.foratom.org) made a total of 44 recommendations targeted at the EU Institutions, national decision-makers and the industry itself. All of these recommendations remain valid and need not be repeated here. The key ones, however, are the following:

The EU decision makers should ensure that:

- an appropriate network of nuclear R&D infrastructures, covering all aspects of the safe long-term use of power plants and the development of new, safe, competitive and sustainable reactor technologies is in place,
- sharing of best practices in terms of the decision-making process with regard to new nuclear projects is promoted and that open and transparent procedures with clear responsibilities and timelines continue to be supported,
- harmonised conditions for the safe long-term operation of nuclear power plants are developed throughout the EU,
- the EC and national decision-makers support the harmonisation of licensing procedures as well as an EU-level reactor design clearance,
- technical leadership, skills and industrial capacities in the nuclear new build supply chain are maintained and developed,
- the EU's energy and trade agendas are linked in order to sustain the leading role of European industrial players globally,
- in nuclear transport, harmonisation of package design licensing procedures is supported such that a container licensed by the Competent Authority of one Member State should be able to be used throughout the EU without having to obtain additional licences.

The national decision-makers should ensure that:

- the national radioactive waste programmes, including final disposal continue to be developed and implemented, in order to assure safety in the long-term. This should be done in accordance with the EU Directive on the management of spent fuel and radioactive waste adopted in July 2011,
- political decisions are taken without undue delay to ensure that geological disposal is implemented. These decisions should be taken in an open and transparent way with appropriate public participation,
- in accordance with the principles set out in the Aarhus convention, national authorities justify decisions made and give feedback on the actual consideration of stakeholders' views in the final decisions regarding construction or dismantling of a nuclear installation,
- more effective information and education directed towards nuclear materials carrier personnel is applied in order for them to fully understand the real risks and precautions.

The nuclear industry should ensure that:

- the safe operation of all nuclear installations is continued,
- the efforts in harmonising safety requirements and thus supporting the European Community framework for nuclear safety are pursued,
- safety standards for the design and operation of new nuclear reactors are developed by the industry in conjunction with WENRA, ENSREG and the European Institutions,
- the efforts to increase the availability factors of NPPs are continued, and hence the sector is continuously driven towards improving its performance record,
- the cost of new nuclear reactors remains competitive,
- EU researchers and companies increase their efforts to remain at the forefront of the growing international nuclear market,
- an industry support (from the nuclear sector but also from the electro-intensive industries) is available to launch a large-scale demonstration for coupling of a nuclear reactor with industrial process heat applications,
- financial provisions are available for the implementation of radioactive waste management programmes and that safety remains the priority,
- nuclear facilities continue to be as open as possible and allow visits by the general public in order to increase its level of knowledge on nuclear matters,
- standardisation of nuclear reactor designs is promoted by the nuclear energy industry with the support of ENSREG and the European Institutions,
- partnerships with universities, technical colleges and engineering schools are supported, and that the creation of master degrees in the appropriate disciplines is encouraged,
- wider dissemination of information relating to the safety of nuclear transport is promoted and that the general public is encouraged to visit transport facilities.

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