Future challenges for nuclear energy in Europe

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Although it cannot yet be considered proven, all the indications are that man-made global climate change is already with us. Although it may take a little longer to prove beyond doubt, in the mean time the only sensible approach is to apply the precautionary principle and to take pre-emptive action. Recognising the importance of these arguments, the European Union has committed itself to meeting the Kyoto Protocol and the recent commitment to meeting a target of 22% of electricity generation from renewables by 2010 is encouraging. The central problem is finding a means by which developing countries can improve their living standards while limiting global carbon dioxide emissions. The developed countries have a moral responsibility to take the lead.

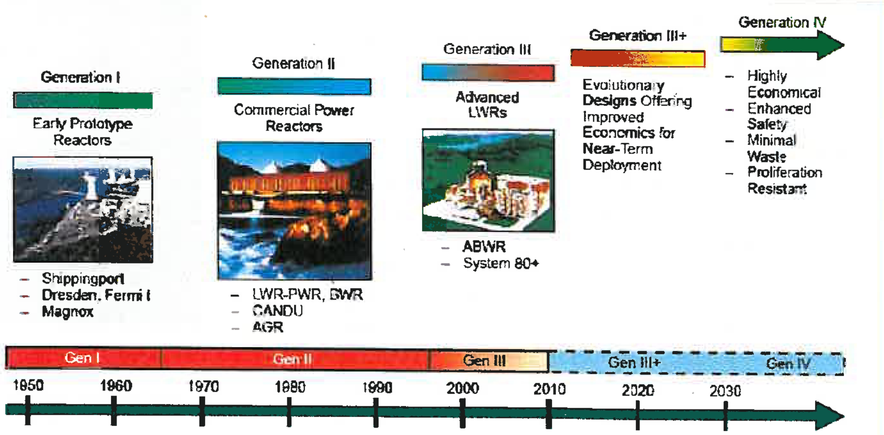
Although the theoretical potential of renewables is very large, placing total reliance on renewables is a risky strategy. Surely a more sensible strategy is to aim for a balanced mix of generation options, using all the options available, including nuclear? The practical difficulties of biomass, wind, wave and solar energy make it a very difficult prospect to meet the target for renewables. Although rapid progress is being made, investment in renewables has so far only been possible with the aid of large subsidies and it is arguable whether they will ever be fully competitive unless electricity prices rise well above current levels. It is ironic that while political support for renewables is relatively easy to come by, this is not presently the case for nuclear power that has for years been helping to reduce carbon dioxide emissions.

Nuclear generation in Europe is already contributing towards reducing carbon dioxide emissions and the European Union would be hard pressed to meet its Kyoto targets without it. Yet apart from Finland and France, there is little government support for new reactors to be built and the prospects are that Europe's nuclear electricity capacity will decrease as old plants reach the end of their lives. If we are not to lose the valuable contribution nuclear generation is already making to carbon dioxide reduction, action is needed now to ensure that new nuclear plants are built to replace old ones as they close down. In the short term, replacement plants will be evolutionary light water reactors (LWRs) such as the European Pressurised Water Reactor (EPR), the first examples of which will be built in Finland and France. Such plants are economically competitive and have a demonstrably good safety pedigree. But in the longer term there is now an international consensus that the so-called Generation IV reactor designs will be needed (see Figure 1).

The motivation behind the Generation IV Initiative, is the recognition that maintaining global nuclear capacity at its current level of roughly 400 GWe will be insufficient to stabilise carbon dioxide emissions in the longer term against a background of increasing energy demand, even if a substantial contribution from renewables is realised. What would be needed would be reactors which could deliver the higher capacity in a manner which would be regarded as long term sustainable. The judgement is that evolutionary LWRs would not be able to fully meet this requirement and this has led to the drive for Generation IV reactors.

Generation IV reactors are intended to satisfy demanding criteria under safety/reliability, long term sustainability, economic competitiveness and proliferation resistance. Generation IV designs would emphasise inherent safety and fault tolerance and it is believed that this would enhance public confidence by making the safety arguments more transparent and accessible. Improved sustainability would extend nuclear fuel supplies into the long term future by recycling used fuel and also enable nuclear to contribute outside the electricity generation sector to include transport by utilising the hydrogen economy. Generation IV reactors would, ideally, be economically competitive without having to invoke any externalities such as carbon credits; their design and construction would minimise investment risks to encourage private investment in deregulated markets. Finally, Generation IV fuel cycles would aim to minimise the inventories and accessibility of weapons-useable materials.

Six reactor systems have been chosen because of their potential to meet the Generation IV goals. These are the gas-cooled fast reactor (GFR), lead-cooled fast reactor (LFR), molten salt reactor (MSR), sodium-cooled fast reactor (SFR), super-critical water reactor (SCWR) and the very high temperature gas reactor (VHTR). While most of these systems can claim, at least to some extent, to build on existing knowledge and experience, they all push the boundaries of existing technology quite far. The Gener-



► **Fig. 1:** The Generation IV initiative is targeting reactor deployment by around 2030

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ation IV Roadmap[1] has identified all the technological gaps that would need to be addressed for each system. Many of these are common to more than one system and the Roadmap identifies several areas where cross-cutting R&D will be required. One of these is fuels and materials; this is useful to highlight here because it illustrates the R&D timescales needed:

The periods of time for selecting, testing and commercial implementation of new materials for nuclear fuel and primary circuit structural components are all very long; even with a fully committed R&D programme as envisaged in the Generation IV Roadmap this phase is expected to last almost 20 years (see Figure 2). The principal reason is the need to conduct extensive irradiation tests to prove the durability of materials under the intense radiation and temperature fields. This constrains the earliest timescale on which Generation IV reactors could be introduced. The necessary R&D will also be very expensive and no single country has the necessary facilities and expertise to carry it out alone, hence the need for international collaboration.

Europe is playing a full role in the R&D needed to underpin Generation IV system. Three European countries (France, Switzerland & UK) are members of the Generation IV International Forum (GIF) in their own right and the EU has now joined, being represented by Euratom. The European contribution is being coordinated through the Euratom 6th Framework programme, which has been developed with Generation IV very much in mind. Several of the proposed projects will form a distinctive European contribution, particularly for VHTR and GFR, which are seen as the top priorities in Europe. The total value of the 6th Framework projects is yet to be determined, but is expected to be in the region of Euro 20m to Euro 40m over a 5 year period.

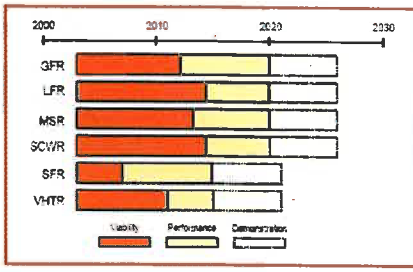
Considering the long R&D timescales and the large expense, it is apparent that the Generation IV reactors will not be able to break into the commercial market without first establishing the correct political conditions. Although Generation IV reactors are expected to be economically competitive without subsidies, private investment cannot be expected to support them through the R&D phase. Government support will therefore be needed that is best regarded as an enabling investment that will create future energy options from which the deregulated markets can later choose. This would be no different to the present situation of renewable energy in Europe; the investment in which is only possible because of heavy subsidisation. In the longer term, the objective is that the investment in renewables will be recouped when investment and operating costs decrease sufficiently for renewables to operate without subsidies. Whereas government support for renewables is presently considered politically acceptable, the same cannot be said for nuclear generation in all European countries. Indeed, many European governments are reluctant to associate themselves with nuclear technology and this imbalance needs to be overcome. This is one of the principal challenges facing Generation IV reactors.

Key issues in Europe, if we are to maintain open the possibility of new reactor build, are skills retention and knowledge preservation:

Nuclear power technology needs to be perceived as an active and interesting area if it is to be successful in attracting new graduates in science and engineering, especially with the shortage of students wanting to study these subjects. The stagnation in reactor construction in Europe over the last decade has not been helpful in this respect and there is a real risk of losing the skills base as the present generation retire. The funding of university courses specific to nuclear science and engineering remains uncertain and this does not help to guarantee the involvement of the university sector in the long term.

Knowledge retention is another critical area of concern. Knowledge accumulated over nearly 50 years is in danger of being lost. Much of this knowledge may potentially be relevant to Generation IV systems and it would be tragic if it were lost at this crucial stage. Fortunately there are some examples where active steps are being taken to preserve historic knowledge. For example, in the UK a database is being built up to preserve information pertaining to the UK's sodium cooled fast reactor programme. The monetary investment in this historic work, in current values, is valued at billions of Euros. Preserving it will safeguard a resource that may potentially save much time and effort in Generation IV. Another example of active knowledge preservation is the OECD/NEA's efforts in preserving knowledge in the areas of fuel performance and reactor physics experiments. In addition to preserving the extraordinarily large amount of information, these activities have successfully encouraged the release into the public domain of information that was previously proprietary; there is general recognition that the benefits of open accessibility of the data outweighs narrower commercial interests.

The reasons why most European governments have distanced themselves from nuclear power technology are principally political and societal and are well outside the scope of this article to analyse. However, it is interesting to note that the inherent inertia of the electricity generation industry has allowed governments to adopt positions which are evidently not defensible in the long term, for the sake of political expediency. An example is the commitment of several European governments to phase out nuclear generation without any coherent strategy for replacement power. Such a position has only been possible because nuclear phase-out has largely meant retaining nuclear plants until their operational lifetimes are expired such that very little capacity has so far actually been lost. The approaching imminence of the closure of old plants and the realisation that Europe's Kyoto obligations are looking increasingly difficult to meet are the reasons why there are now signs that some European governments are now starting to reconsider. The long timescales required for the deployment of new reactors means that the options for responding to changing demands are very limited. Some politicians would prefer to defer decisions of Europe's nuclear future until renewables have been given an opportunity to deliver. Unfortunately, by the time this becomes clear, it may well be too late to obtain the fullest advantage of nuclear generation. Even if renewables prove able to meet their target in Europe, they would barely match the contribution that nuclear is already making at present and further carbon savings will be needed. Faced with the extreme dangers of global climate change, the only sensible strategy is to keep the nuclear option open.



◄ **Fig. 2:** The progression of R&D activities is in 3 phases; viability, performance and demonstration

[1] "A technology Roadmap for Generation IV Nuclear Energy Systems", Generation IV International Forum, December 2002, GIF-002-00