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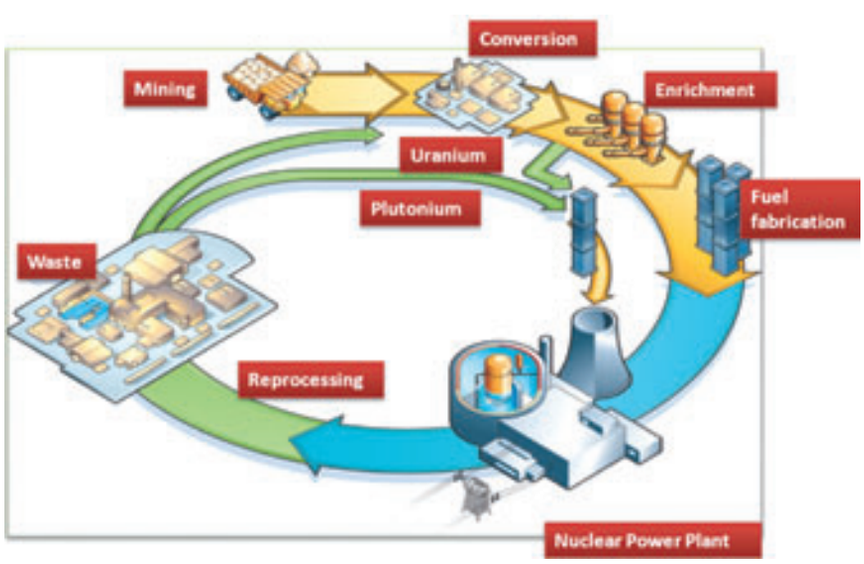
Global nuclear energy outlook

Nuclear generation is used to supply 16% of the world's electricity, with use in 30 countries. In Europe, it is the largest single generation source, supplying around a third of the electricity. Uranium is mined in many of the countries using nuclear generation, as well as other countries, including Kazakhstan and Australia.

Although commercial nuclear generation of electricity began in the late 1950s, there has only been significant growth since 1970. The number of reactors coming online peaked around 20-25 years ago, although new additions to the grid have continued. A significant proportion of the increase in nuclear power output over the past twenty years has resulted from improved operating performance of existing plants and capacity upgrades.

Nuclear generation is part of a larger nuclear fuel cycle. Uranium ore is mined, either mechanically or by *in situ* leaching. After conversion to uranium fluoride, the uranium is enriched to increase the proportion of the U^{235} isotope from the natural abundance of 0.7% to around 3-5%. The enriched uranium fluoride is converted to an oxide and formed into small fuel pellets, which are placed in fuel assemblies, several metres high. These assemblies are typically used in nuclear power plants for around three years. After three years the used nuclear fuel can either be stored for eventual disposal in a used fuel repository, or it can be recycled by reprocessing the fuel to separate unused uranium and plutonium, which is produced in the nuclear reactor during nuclear generation, from the waste fission products. Around 97% of used nuclear fuel is potentially recyclable.

Below: Nuclear generation is part of a larger nuclear fuel cycle, from mining to waste and reprocessing.



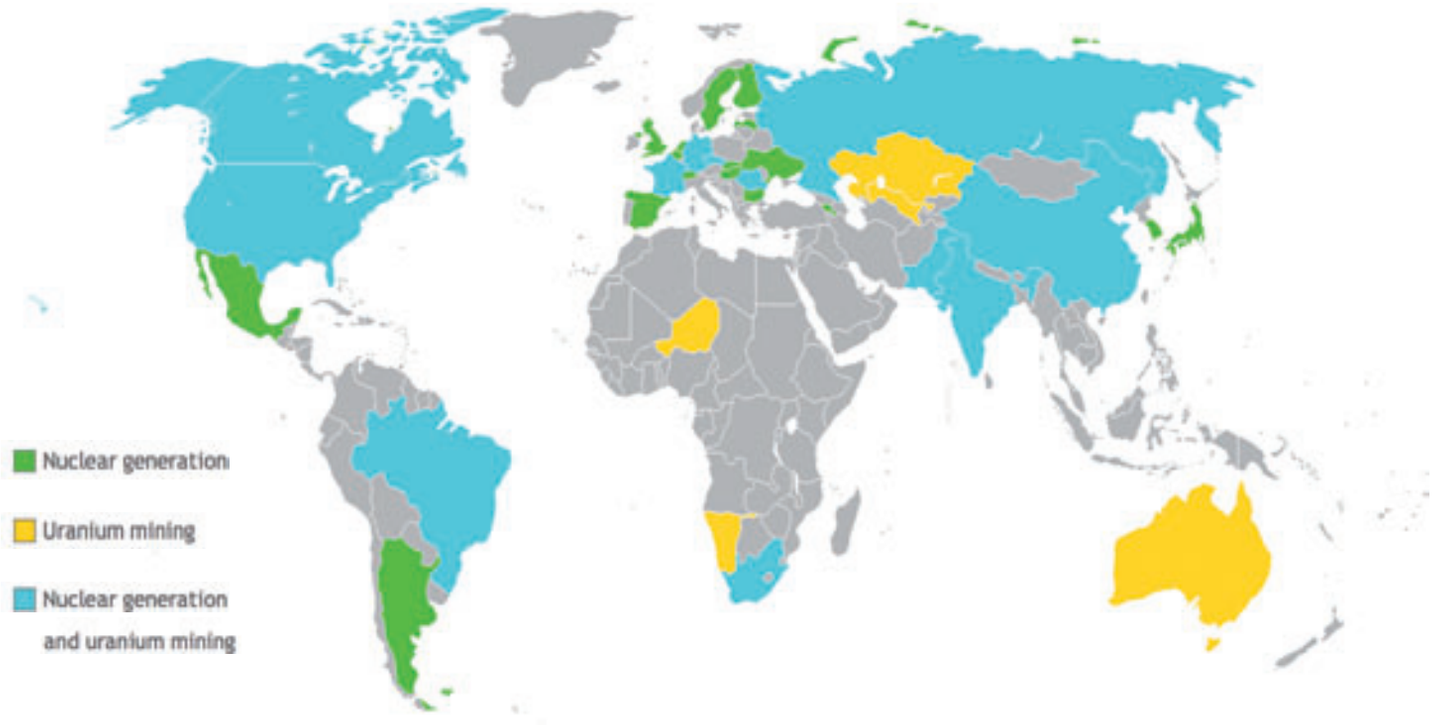
The nuclear industry supporting this fuel cycle is fragmented, in comparison with the oil and gas sector. The industry lacks large supplier companies with the power to influence opinion. Many of the larger companies involved in the nuclear industry have a much broader portfolio of activities. Organisations such as the World Nuclear Association help keep people in the industry in touch, and represent the industry in the broader industrial and political community.

Prospects for new nuclear generation

There is now renewed interest in nuclear energy, prompted by growing demand for clean, reliable and secure energy. Nuclear energy is a clean energy source, with very low greenhouse gas emissions across the entire nuclear fuel cycle. The growing realisation of the need to reduce global greenhouse gas emissions has strengthened interest in nuclear generation, as an alternative to baseload generation from fossil fuels.

Even putting aside the imperative of reducing greenhouse gas emissions, massive investment is needed in the energy sector over the next 25 years to renew existing infrastructure and meet expanding demand. It is predicted that an increasing proportion of energy supply will come from electricity generation. The rapidly expanding industrial powerhouses of China and India are investing in new nuclear capacity to provide the reliable supplies that their industry needs.

Nuclear power is also becoming more attractive from an economic perspective. New 'Generation 3+' designs and improved project management are helping to reduce the costs of nuclear generation. Furthermore, as emissions trading and carbon taxes are playing an increasing part in energy economics, the economic case for nuclear power, in comparison to fossil fuels, is improving. The nuclear industry is learning the lessons of past mistakes. Standard designs help reduce the costs of series build.



Above: The current status of nuclear generation and uranium mining. Nuclear generation is in use in 30 countries around the world.

Finally, increasing reliance on imported fossil fuels is a threat to security of energy supplies, especially for the UK as its own domestic reserves dwindle. Uranium supplies are widespread and some of the largest deposits are found in politically stable countries, such as Canada and Australia.

Europe

In Europe, the somewhat anti-nuclear attitudes of the 1990s have given way to a more positive climate. The political decisions to phase out nuclear generation in Sweden and Germany are unlikely to be repeated elsewhere, and even in those countries attitudes have changed. The majority of the public in Sweden support continued operation of Sweden's nuclear power plants and in Germany there is speculation that the next general election could result in a reversal of its phase-out policy, which was imposed by a minority 'green' party as a part of a coalition agreement.

Construction is underway for the first European Pressurized water Reactor (or Evolutionary Pressurised water Reactor) in Finland and a second is planned in France. Plans for new reactors are widespread in Eastern Europe, including an ambitious programme in Russia. In the UK, there has been a significant turnaround in the political climate. In addition, a recent survey shows that the majority of the UK public believe nuclear generation will play an increasing role in electricity generation.

Americas

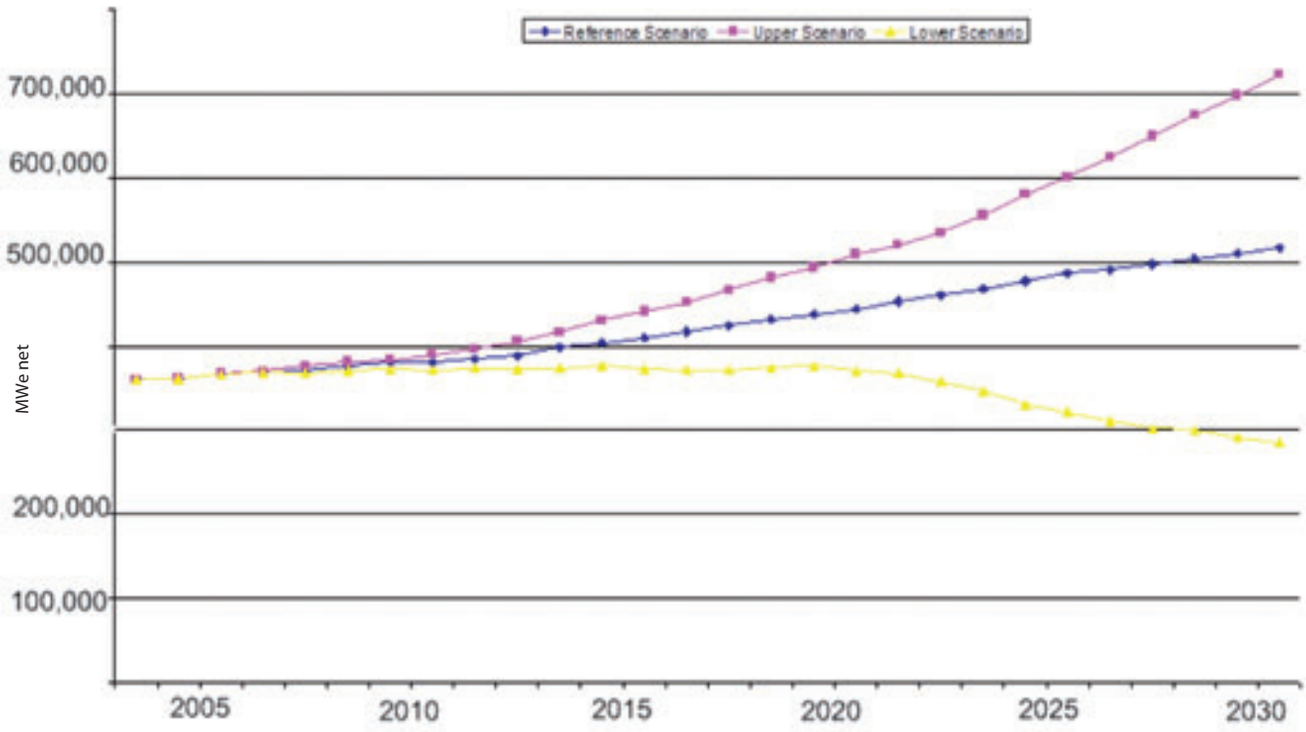
In the US, a new generation of nuclear reactors is planned. Preliminary design certifications are taking place. Consortia have been formed to press forward on Combined Construction and Operating License (COL) activities. However, elsewhere in the US, the Yucca Mountain nuclear waste repository is progressing very slowly. The Global Nuclear Energy Partnership, recently announced by the President, may indicate a change in US back-end policy, with more emphasis on recycling nuclear fuel, rather than disposing of it. In Canada, the announcement of coal plant closures in Ontario resulted in renewed interest in nuclear generation. Existing reactors are being refurbished for extended operation and new reactors are planned. In South America, new reactors are planned in Argentina and Brazil, and Chile is exploring the potential of nuclear power.

Asia

China is investing strongly in nuclear generation, forming partnerships with several western companies. 40GWe (four times the current UK generation capacity) is proposed by 2020. India's nuclear programme is moving forward after forging an agreement with the US that could lead to greater international participation. The Japanese nuclear industry is still recovering from the effect of a large earthquake on the Kashiwazaki Kariwa nuclear site. The magnitude 7.8 earthquake caused devastation to the region, but caused only minor damage to key buildings at the Kashiwazaki Kariwa site. Many other countries in Asia are also interested in developing nuclear power, from Indonesia to Gulf States.

Africa

In Africa, commercial nuclear generation has so far been limited to South Africa. The Pebble Bed Modular Reactor is being developed in South Africa by PBMR Ltd. With an output of around 160MWe, the smaller size is particularly suitable for emerging electricity markets. PBMR has plans to use pebble bed reactor technology for both electricity and process heat production. The PBMR reactor will operate at more than 900ºC and could be used for hydrogen production, as well as desalination.



Above: The World Nuclear Association's scenarios for the nuclear industry. A reference case is based on the most likely outcomes, with upper and lower cases indicating outliers.

The World Nuclear Association's scenarios for the nuclear industry

The World Nuclear Association (WNA) develops scenarios for future nuclear generation capacities, based on the expertise of its 140 member companies. A reference case is based on the most likely outcomes, with upper and lower cases indicating outliers.

Over a period of 20 to 25 years, the reference scenario predicts a 40% increase in nuclear generation capacity. The upper case envisions around a 100% increase in nuclear capacity, and even the lower case predicts capacity would fall to only 80% of current levels. However, because the overall global electricity generation capacity is expected to grow significantly up to 2030, all scenarios apart from the upper scenario predict a reduction in the overall share of electricity generated from nuclear power.

	nuclear	coal	gas
Finland	2.76	3.64	-
France	2.54	3.33	3.92
Germany	2.86	3.52	4.90
Switzerland	2.88	-	4.36
Netherlands	3.58	-	6.04
Czech Rep	2.30	2.94	4.97
Slovakia	3.13	4.78	5.59
Romania	3.06	4.55	-
Japan	4.80	4.95	5.21
Korea	2.34	2.16	4.65
USA	3.01	2.71	4.67
Canada	2.60	3.11	4.00

Right: Some comparative electricity generating cost projections for 2010 (in US 2003 cents/kWh, with discount rate 5%, 40-year lifetime, and 85% load factor).
Source: OECD/IEA NEA 2005.

Sources of new nuclear generation

New nuclear generation will come from a number of sources; firstly, life extensions to existing reactors. The UK's first generation Magnox reactors were built with a design life of 20-25 years. Some have operated for twice that. In the US, many LWR reactors with a design life of 40 years now have 20-year extensions. Such life extensions have a strong economic incentive, being cheaper than building new capacity and deferring decommissioning. However, technical feasibility and safety are paramount considerations. Not all reactor types are suitable for lifetime extensions. In addition, there is a case that the industry should be moving to new reactor construction to retain construction skills and to promote research and development in more advanced reactors designs.

To 2020 and beyond, new reactors will be based on existing Generation III and 3+ designs. However, beyond 2020, new reactor technologies based on Generation IV technologies, with enhanced safety, proliferation-resistance and more efficient fuel performance will emerge.

Ensuring successful new build

If the nuclear industry is going to successfully achieve sustained, economic expansion, important lessons must be learned. Current reactors have low marginal costs, typically 1-1.5 Euro cents/kWh. These nuclear plants, if reliable in operation, should make significant profits for owners.

Why then is there not more activity to build new nuclear power plants? New reactors involve relatively high

capital costs, and with new designs such as the EPR, AP 1000 and others being considered, there is some uncertainty over the costs. Despite this, the industry is confident that overnight capital costs of $1500-2000/kWe are realistic.

A 2005 OECD comparative study showed that nuclear power had increased its competitiveness over the previous seven years. The principal changes since 1998 were increased nuclear plant capacity factors and rising gas prices. The study did not factor in any costs for carbon emissions from fossil fuel generators, and focused on over 100 plants able to come on line between 2010-15, including 13 nuclear plants. Nuclear overnight construction costs ranged from US$1000/kW in Czech Republic to US$2500/kW in Japan, and averaged $1500/kW. Coal plants were costed at $1000-1500/kW, gas plants $500-1000/kW and wind capacity $1000-1500/kW.

"The industry lacks large supplier companies with the power to influence opinion"

There are some issues to overcome before substantial new nuclear build. One such issue is the lack of capacity worldwide for the construction of major reactor components, such as large forgings. However, with reactor vendors already placing orders, new investment will be encouraged. Although some have suggested that the nuclear industry will not be able to expand sufficiently quickly to meet energy and climate change demands, it should be remembered that around 200 reactors came on-line in the 1980s alone. There are also concerns about the aging workforce in the nuclear industry. However, greater optimism is allowing new hirings. The industry is carrying out a number of initiatives to ensure that a new generation of nuclear engineers will emerge. In addition, the WNA, in collaboration with the International Atomic Energy Agency, has established the World Nuclear University, to broaden the skills of young industry leaders.

Financing will be a key issue for nuclear investment. There is a conflict between long-term environmental concerns and the high borrowing costs of capital-intensive projects that may address those concerns. Understanding and mitigating these risks and uncertainties can allow investors to take a longer-term view. New nuclear power plants should be attractive to investors with long-term liabilities, such as pension and life assurance funds.

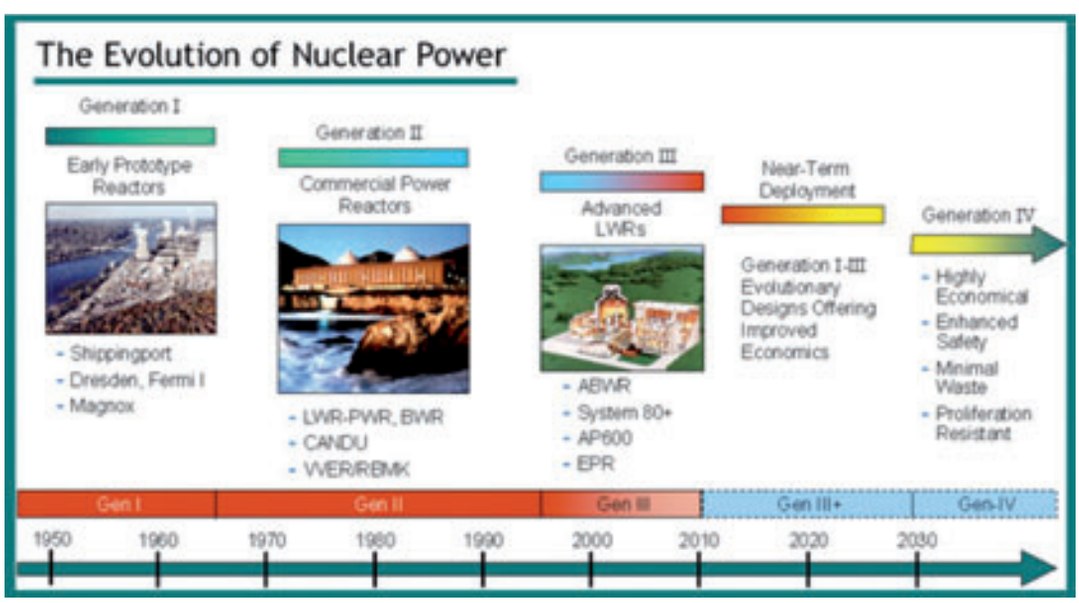
New nuclear build projects will have large capital costs, (relatively) long schedules and varying risk profiles. Lenders will require strong debt coverage and overrun funds, but at the same time certainty of the start of repayments. Success should follow, provided investment:

- is made in well-designed 'economic' plants supported by stable regulatory regimes;
- risk is shared among all project stakeholders;
- strong project teams are utilised, along with extensive project planning.

In conclusion

Nuclear energy will supply reliable, low carbon electricity, and will form a significant component of the global energy mix in the 21st century. New build in Europe and North America is part of the strengthening 'nuclear renaissance,' but new projects in Asia, Africa and South America are part of on-going growth in the use of nuclear energy.

There will be strong demand for the supply of nuclear components. Companies are taking steps to secure supply, but shortages could result during the early phase of the nuclear renaissance in Europe and North America. The uranium fuel market has responded strongly to short-term supply concerns. In the longer term, adequate supplies are expected to 2030 and beyond. New nuclear generation capacity deployment, particularly in Europe and the US, will be enabled by regulatory efficiency, project financing that supports initial high capital cost and strong project management.



Left: The evolution of nuclear power. To 2020 and beyond, new reactors will be based on existing Generation III and 3+ designs. Beyond 2020, Generation IV technologies, with enhanced safety, proliferation-resistance and more efficient fuel performance will emerge.