

# Nuclear Power

by Alan McDonald

# Global Status

*A look at nuclear power generation around the world and its future prospects.*

Today's debate about nuclear power generation must take into account three principal realities.

First, expectations for nuclear power are rising.

Second, 'one size does not fit all', meaning that you cannot answer questions like 'Is nuclear power economic?' with a single universal answer. As with just about everything else in life, the answer is 'it depends' — sometimes yes, sometimes no. One size, certainly in the case of nuclear power, does not fit all.

The third element is economics. Whether nuclear power lives up to the rising expectations will depend on how cheap it is compared to alternative energy sources. Certainly, the nuclear industry can influence this issue by bringing down costs, but there are factors outside the industry's control, such as the price of natural gas or of carbon credits, that will also determine, for any particular investor, whether nuclear is a cost-effective option.

## A Look at the Record

Global nuclear capacity grew at a fast pace from 1960 to the mid-to-late 1980s, and its share of global electricity reached 16% in 1986. Growth in capacity then slowed (see graph **Projections of Nuclear Generation Capacity** on page 47), but nuclear power's 16% share of electricity held roughly steady for the next 20 years. Its steady 16% share meant that nuclear electricity generation was steadily growing at the same pace as overall global electricity generation. This was due to the slow continuing capacity growth and due to a steady rise in reactor availability factors during the 1990s (see graph on **Increase in Nuclear Power Capacity and Generation** on page 48). The energy availability factor is the amount of electricity that a reactor is available to produce if it ran full time for the whole year at its rated power.

Availability factors rose in the 1990s for several reasons, principally technological and managerial

improvements, deregulation, and safety improvements.

Technological and managerial improvements are the most straightforward. Every industry constantly improves, taking advantage of new materials, new computers, new quality control procedures and the like. The nuclear industry was and is no different.

Deregulation meant that cost savings from such improvements were not automatically passed on to customers in the form of lower electricity prices, but might be partially retained by a utility as profits. This raised the incentive to boost availability factors.

Major safety improvements were introduced after the Chernobyl accident in 1986. The accident prompted a real shift towards sharing of best practices, peer reviews, incident reporting and mutual learning. This was done in the interests of safety, but it also had the additional effect of improving performance and availability factors. A safer plant turns out to be a more profitable plant.

As is suggested by the right side of graph **Increase in Nuclear Power Capacity and Generation**, the rise in the world average availability factor has levelled off in the last few years. Partly for that reason, nuclear electricity dropped to only 15% of the global electricity supply in 2006.

## The World at a Glance

The present situation in nuclear power generation throughout the world is extremely varied. In the 30 countries that have nuclear power generation capacity, the percentage of electricity coming from nuclear reactors ranges from 78 % in France to just 2 % in China.

All told, as of March 2008, there are 439 nuclear power plants around the world, while 35 more are under construction. The USA has the most with 104,

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France is next with 59, then Japan with 55 and Russia has 31 and seven more under construction.

The expansion in nuclear power generation is centered in Asia. A total of 20 of the 35 plants under construction are in Asia, while 28 of the last 39 plants connected to the grid are also in Asia.

## Rising Expectations

There is more and more talk about nuclear power generation, often in relation to wider issues such as global warming and climate change. This renewed attention is encouraging a public debate on the pros and cons of this technology involving the media, politicians and the general public alike. But will these rising expectations be matched by facts in the field?

The IAEA Department of Nuclear Energy produces two projections of worldwide installed nuclear generation capacity, a low one and a high one, which are updated yearly.

The low projection includes firm plans announced by governments and power utilities for new construction, lifetime extensions and retirements. In this scenario, there would be moderate steady growth to reach a total of 447 GW(e) in 2030. The high projection adds reactors suggested by long term government and utility plans. Total capacity goes up to 691 GW(e) in 2030. In terms of electricity production, the increase through 2030 would be 25% in the low projection and 93% in the high.

The bars on the right of **Projections of Nuclear Generation Capacity** show where the expansion of nuclear power is projected to take place. For the next few decades, even in the high projection, nuclear power will remain mainly a technology of developed countries, and big developing countries.

Thus, if today's rising expectations are met, the big increases will likely be because the countries that already use nuclear power will have built more, not because new countries, whether developed or developing, have decided to start new programmes. But new countries will definitely have entered the game. In the high projection, approximately 20 more countries have nuclear power plants in 2030 than do today.

## The Driving Factors

What is driving rising expectations for nuclear power generation? Five possible reasons.

First is the track record. The world now has around 12,700 reactor-years of experience. The performance and safety records of the designs in operation today are extremely good.

Second, energy forecasts keep showing persistent long-term growth.

Third is energy supply security. In the 1970s concerns about supply security, triggered by the oil shocks, were a major cause of nuclear expansion in both Japan and France. Similar concerns may also prove an important factor today.

Fourth, specific substantial expansion plans in key countries, like China and India, have a big impact on overall global expectations.

Finally, new environmental constraints — like entry-into-force of the Kyoto Protocol — mean that there are some real financial benefits to avoiding greenhouse gas (GHG) emissions.

## Asia: Expanding Scene

But what is the outlook for nuclear power generation in individual countries around the world? Our overview starts with the countries of Asia, the world's region where most of the expansion is taking place.

### India

India gets less than 3% of its electricity from nuclear, but it is, along with China and Russia, one of the leaders in current new construction, boasting six of the world's 35 reactors under construction.

India's future plans, however, are even more impressive: an eight-fold increase by 2022 to 10% of the electricity supply and an overall 70-fold increase to 2052 to 26%. A 70-fold increase figure certainly sounds remarkable, but it works out to be an average growth rate of 9.5% per year, which is a bit less than the average global nuclear growth from 1970 through 2002. So it is hardly unprecedented.

### China

China, like India, faces a steep growth in energy demand and is trying to expand its generating capacity using all possible energy sources, including nuclear power. China has six reactors under construction and plans nearly a five-fold expansion by 2020.

However, because the country's energy demand is growing so fast, that would still amount to only

4% of electricity generated by then. Looking ahead, China is a potential supplier of technology and services, particularly in Asia.

### Japan

Moving across the Sea is Japan, a country with 55 reactors, one more under construction and plans to increase nuclear power's share of electricity from 30% in 2006 to over 40% before 2020.

### Republic of Korea

Another Asian country with a significant commitment to nuclear technology is South Korea, which has 20 reactors in operation and three more under construction. Nuclear power already supplies nearly 40% of South Korea's electricity.

## Europe: Mixed Picture

Europe is a fitting example of the 'one size does not fit all' principle.

Russia has 31 operating reactors, seven under construction and significant expansion plans. As part of President Putin's initiative on Global Nuclear Energy Infrastructure Russia is also taking steps towards providing eventual integrated full fuel-cycle services, including possibly leasing fuel, reprocessing spent fuel for countries that are interested in it, and even leasing reactors.

Altogether, the rest of Europe has 167 reactors in operation and six under construction. But within Europe there are nuclear prohibition countries like Austria, Denmark and Ireland; phase-out countries like Germany and Belgium; and expansion countries like Finland, France, Bulgaria, and the Ukraine. In 2005, Finland started construction on Olkiluoto-3, which is the first new Western European construction since 1991. France started construction on Flamanville-3 in 2007.

The UK, with 19 operating plants, most of which are relatively old, had been the biggest wild card until January 2008, when it decided that investors should have the option of building new nuclear power plants on its territory and that the government should reduce regulatory and planning risks.

The three Baltic States, together with Poland, have agreed in principle to construct a nuclear power plant in Lithuania by 2015, and Lithuania passed the necessary legislation in 2007 to make construction possible. Turkey also passed new legislation to enable nuclear power plant construction.

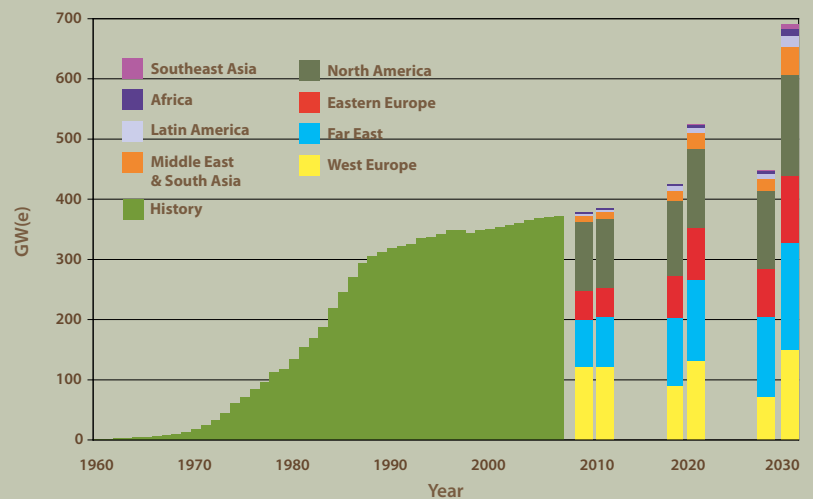
## The Americas: Changing Landscape

Like Europe, the Americas have a varied landscape.

### USA

The USA has 104 reactors providing 19% of the country's electricity. For the last couple of decades, the main effort has been directed towards the improvement of availability factors, power uprates at existing plants and getting license renewals. Presently, 48 reactors have already received 20-year renewals, thus extending their licensed lifetimes to 60 years.

### Projections of Nuclear Generation Capacity worldwide, 2020-2030



*Nuclear power generation is projected to grow mainly in regions where it is already established.*

source: IAEA

Altogether, three-quarters of the US reactors either have license renewals, have applied for one, or have stated their intention to apply. But until recently, the business case for building new nuclear generating capacity has not been there in the USA. Coal is plentiful, natural gas has been cheap and there are no Kyoto limits to cap GHG emissions. Besides, investors have been leery of financial risks and delays that could come from nuclear projects.

There are signs, however, that things might be about to change. In 2007, one US reactor that had been laid-up for decades was restarted, and active construction was restarted on another reactor. For new construction, the Energy Act of 2005 includes loan guarantees, tax credits and other tools to reduce financial risks. In 2007 the Nuclear Regulatory Commission issued its first early site permits (ESPs), certifying three sites as suitable for new construction, and it is processing two more ESP applica-

tions. Also in 2007, it received four applications for combined licences (COLs), the first applications for new nuclear reactors in the USA in nearly 30 years. It expects a total of 21 such applications, for a total of 32 reactors, by the end of 2009.

### Canada

Canada has 18 reactors generating 16% of its electricity need. Two utilities have filed site preparation applications for potential construction of new units in Ontario, while last year Energy Alberta applied for a site licence for a new nuclear power plant in north-west Alberta.

### Argentina, Brazil and Mexico

Argentina, Brazil and Mexico each have two reactors, and Argentina has one under construction. Any further new construction in the near term would most likely take place in Argentina and/or Brazil.

### Africa

In the African continent, South Africa is the only country with operating power reactors — it has two. South Africa is also working on demonstrating a new small reactor of its own design.

### Nuclear 'newcomers'

Twelve of the thirty countries with operating nuclear reactors are now building more, and a handful of others are considering it seriously. Iran is the one country without any operating plants that is building one. In addition to countries mentioned above several developing countries, such as Indonesia, Egypt, Jordan and Vietnam, have talked about the possibil-

ity of developing a nuclear power plant and taken initial steps. However, even if today's rising expectations come to pass, the big increases over the next few decades will be in the regions that already have running nuclear programmes.

## Closing the Cycle


Whenever nuclear power generation is debated, the issue of spent fuel arises. While France, China, India, Japan and the Russian Federation reprocess (or store for future reprocessing) most of their spent fuel, Canada, Finland, Sweden and the USA have opted for direct disposal. Meanwhile, most countries have not yet decided which strategy to adopt. They are storing spent fuel and keeping abreast of developments associated with both alternatives.

However, there are several initiatives to reduce the long-lived radiation burden from highly radioactive waste. In February 2006, the US announced a Global Nuclear Energy Partnership (GNEP) which includes the development of advanced recycling technologies. Meanwhile, France has a three-axis strategy: partitioning and transmutation to reduce the long-lived burden; both retrievable and non-retrievable geological repositories; and conditioning and long-term storage. Other countries are doing research on ways to reduce high level waste.

## The Bottom Line

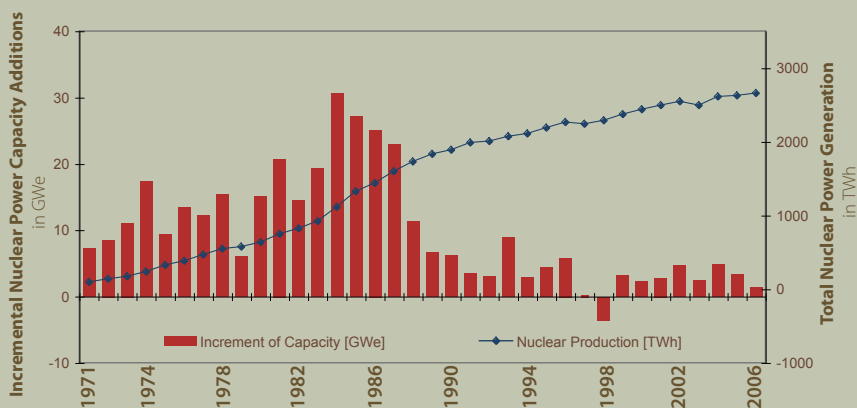
Compared to fossil fuelled alternatives, nuclear plants are expensive to build but cheap to run. That makes nuclear an attractive option for some investors in some situations, but not the energy source of choice for all.

In general, nuclear power is more attractive where energy demand is growing rapidly, such as China and India; where alternatives are scarce or expensive, for example in Japan and South Korea; where energy supply security is a priority, such as Japan and Korea again, and possibly Europe looking ahead; where reducing air pollution and GHGs is a priority; where financing can be long-term, and where there is a low financial risk.

The bottom line is that the realization of nuclear's rising expectations rests on economic realities. 

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## Increase in Nuclear Power Capacity and Generation 1971-2006



Nuclear power generation has been going up faster than the increase in capacity.

source: IAEA