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Uranium and Nuclear

Contents

Strategic insight

This Commentary is based on the findings of the WEC report Global Nuclear Energy: One Year Post Fukushima published in 2012 and on the information and data provided by the International Atomic Energy Agency and WEC Member Committees.

1. Uranium

Uranium is a naturally-occurring element in the Earth. Traces of uranium can be found practically everywhere, although mining takes place in locations where uranium is naturally concentrated. To produce nuclear fuel from the uranium ore, uranium has to be enriched and formed into pellets which are loaded into the reactor fuel rods. Uranium is mined in 20 countries, although about half of world production comes from just ten mines in six countries: Australia, Canada, Kazakhstan, Namibia, Niger and Russia. In the conventional mining, the ore goes through a mill where it is crushed and then ground in water to produce a slurry of fine ore particles suspended in the water. The slurry is leached with sulphuric acid to dissolve the uranium oxides, leaving the remaining rock and other minerals undissolved.

Today, nearly half the world's mines use in situ leaching (ISL), where groundwater injected with oxygen is circulated through the uranium ore, extracting the uranium. The solution containing dissolved uranium is then pumped to the surface. This mining method does not cause any major ground disturbance. Both mining methods produce a liquid with dissolved uranium. The liquid is filtered and the uranium is separated by ion exchange, filtered and dried to produce a uranium oxide concentrate (U3O8), which is then sealed in drums. This concentrate has a bright yellow colour and is called 'yellowcake'. The U3O8 is only mildly radioactive. The radiation level one metre from a drum of freshly-processed U3O8 is about half that experienced from cosmic rays on a commercial jet flight.

The uranium market has been in decline over the past decade. Total annual mine production has fallen below the fresh fuel requirements of all operating reactors in the world. This is a consequence of the on-going disarmament and an emerging "secondary" market for reactor fuel from warheads and other military and commercial sources. The "secondary" market drastically reduced demand for fresh uranium and this reduction in demand was amplified by the new suppliers from Russia, Kazakhstan and Uzbekistan. At its lowest, the total global production of uranium fell down to about 60% of the annual reactor fuelling requirements.

The recent assessments of global uranium resources show that total identified resources have grown by 12.5% since 2008. However, the costs of uranium production have also increased. As of 1 January 2011 the total identified resources of uranium are considered sufficient for over 100 years of supply based on current requirements.

Global uranium production increased by over 25% between 2008 and 2010, mainly because of increased production by Kazakhstan, the world's leading producer. The uranium resource and production capacity have grown over the past few years reflecting a 22% increase in uranium exploration and mine development activities between 2008 and 2010, which in 2010 surpassed US$2 billion.

Along with the production, uranium enrichment capacity markets are changing. China, for example which is already using Russian centrifuges, has reached 1.3 million SWUs and has recently agreed with Russia to add further 0.5 million SWUs. Limited enrichment facilities for domestic needs exist in Argentina, Brazil, India and Pakistan. Ukraine joined Armenia, Kazakhstan and the Russian Federation as members of the International Uranium Enrichment Centre (IUEC).

The IUEC was established in 2007 in Angarsk, Russian Federation, following calls by the IAEA's Director General and the Russian President to work towards multinational control of enrichment and create a network of international centres, under IAEA control for nuclear fuel cycle services, including enrichment.

Total global fuel fabrication capacity is currently about 13 000 tU/yr (enriched uranium) for light water reactor (LWR) fuel and about 4 000 tU/yr (natural uranium) for PHWR fuel. Total demand is about 10 400 tU/yr. Some expansion of current facilities is under way in China, Republic of Korea and the USA. The current fabrication capacity for MOX fuel is around 250 tonnes of heavy metal (tHM), mainly located in France, India and the UK, with some smaller facilities in Japan and the Russian Federation. Additional MOX fuel fabrication capacity is under construction in the USA to use surplus weapon-grade plutonium. Genkai-3 in Japan started operating with MOX fuel in November 2009, making it the first Japanese reactor to use MOX fuel. Worldwide, 31 thermal reactors currently use MOX fuel.

The total amount of spent fuel that has been discharged globally is approximately 320 000 tHM. Of this amount, about 95 000 tHM has already been reprocessed, and about 310 000 tHM is stored in spent fuel storage pools at reactors or in away-from-reactor (AFR) storage facilities. AFR storage facilities are being regularly expanded, both by adding modules to existing dry storage facilities and by building new ones. Six countries operate reprocessing facilities and recycle parts of the plutonium in the form of MOX for reuse in nuclear power plants. Some countries build up plutonium stockpiles for fuelling future fast-breeder programmes. Total global reprocessing capacity is about 5 000 tHM/yr.

The Swedish Nuclear Fuel and Waste Management Company (SKB) selected Östhammar as the site for a final spent-fuel geological repository in June 2009, following a nearly 20-year process that narrowed the list of voluntary applicant sites to two in 2002. Subsequent site investigations concluded that the bedrock in Östhammar was more stable with less water than that in Oskarshamn, the other potential site.

Site investigations for repositories at Olkiluoto in Finland and in the Bure region in France continued on schedule with operation targeted for 2020 and 2025 respectively.

In the USA, the Government decided to terminate its development of a permanent repository for high-level waste at Yucca Mountain, while continuing the licensing process. It plans to establish a commission to evaluate alternatives.

Market trends

Demand for uranium is expected to continue to rise for the foreseeable future. Although the Fukushima Daiichi accident has affected nuclear power projects and policies in some countries, nuclear power remains a significant part of the global energy mix accounting for more than 13% of global electricity production. While some countries have plans for development of nuclear power, with the strongest expansion expected in China, India, the Republic of Korea and the Russian Federation, the overall global trend is still unclear. The long lead times (typically ten years or more in most producing countries) necessary to develop uranium production facilities require timely decisions.

Technical and economic considerations

There also are alternative technologies with far smaller fuel requirements. Fast reactors for example operating in a closed fuel cycle could provide energy for thousands of years. They represent a versatile and flexible technology which can create or "breed" more fuel than it is spending by converting nuclear "waste" into "fissile" material. "Fissile" material is nuclear fuel, usually uranium or plutonium that can sustain a fission chain. The heat generated by that fission chain reaction contained within a nuclear reactor produces steam to drive turbines and produce electricity.

"Waste" to Energy

The technology relies upon a "closed fuel cycle", which means that spent fuel is reprocessed after its initial use in a reactor. Instead of sending the spent fuel into storage and eventually long-term disposal, the materials are reused, in particular the "fertile" material. The "fertile" material is not fissionable, but it can be converted into fissionable material by exposure to radiation in a reactor. Once converted into fissile material, it will be consumed in the chain reaction. This conversion from "fertile" to "fissionable" material significantly improves nuclear fuel efficiency and economics. Fast reactors can thus be used to breed more fissile material than they consume or to burn nuclear waste or for a combination of these two operations offering significant benefits in making nuclear energy production more sustainable, both in technical and economic terms.

Fast breeder technology was developed in the 1960s with demonstration and prototype reactors in a number of countries, including China, France, Germany, India, Japan, the Russian Federation, the United Kingdom and the United States. There are 12 experimental fast reactors and six commercial size prototypes with output of 250-1200 MW that have been constructed or are in operation.

The Russian Federation currently operates the most powerful commercial fast reactor, the BN-600 in Beloyarsk, and building the BN-800. The recently released Federal Target Programme *New Generation Nuclear Power Technologies for 2010-2015 With Outlook to 2020*, outlines Russia's plans to develop several fast reactor technologies and corresponding fuel cycles.

A number of other initiatives, including the Generation IV International Forum and the IAEA's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), include research on fast reactor technology. Experts expect that the first Generation IV fast reactor demonstration plants and prototypes will be in operation by 2030 to 2040.

On 3 December 2010, the IAEA Board of Governors authorised the IAEA Director General to establish a reserve of low enriched uranium (LEU), or an "IAEA LEU Bank" owned and managed by the IAEA. The bank will help secure supplies of LEU for power generation in case of supply disruptions which cannot be addressed by the commercial market, State-to-State arrangements or by other means. This initiative does not in any way influence individual countries' rights to establish or expand their own nuclear fuel production.

Donors have pledged about 125 million US dollars and 25 million Euros to cover the initial operational expenses and the purchase of LEU for the IAEA LEU bank. The operating costs of the bank will have no financial implications for the IAEA regular budget. These financial resources will be sufficient to meet the fuel fabrication needs for two to three reloads of fuel for a 1,000 MW(e) light water reactor. The LEU will be made available to an eligible IAEA Member State at the market price and the proceeds will then be used to replenish the stock in the IAEA LEU bank. As a mechanism of last resort, LEU can only be supplied to a Member State upon an advance payment and meeting a set of criteria.

Donors' contributions:

	Pledged	Paid
Kuwait	US$10m	In full
Norway	US$5m	In full
United Arab Emirates	US$10m	0
United States	US$49.540m	In full
European Union	€25m	€20m
Nuclear Threat Initiative	US$50m	In full

2. Nuclear

The first nuclear reactor was in the world was commissioned in the Former Soviet Union Obninsk Nuclear Power Plant in 1954. Since then, the nuclear industry has developed over three distinct periods:

1. The first "fast growth" period between 1954 and 1974 witnessed an average growth rate of about seven reactors per year until 1965, increasing to about 37 reactors per year in 1970 and more following the first oil shock of 1973-1974.

2. The second period from the late 1970s to the mid-2000 was a period of extremely low development, averaging additions of 2-3 new reactors per year only. High capital costs of nuclear and low oil and gas prices were the main factors resulting in the slowdown. The situation was aggrevated further by the two major nuclear accidents: the Three Mile Island (USA, 1979) and the Chernobyl (Ukraine, 1986).

3. The third period from the mid-2000s until the beginning of 2011 once again witnessed an accelerating growth called the "nuclear renaissance". In terms of geographical distribution, the growth was no longer in the OECD countries but mainly in the quickly developing Asian economies (mainly China). That growth was also justified by nuclear's relative cost-effectiveness compared to fossil fuels. In addition, environment, political decisions and weak public opposition in the main countries of growth were the main contributing factors.

Despite the identified negative developments throughout these three periods, the total nuclear production has been growing and reached the annual production of about 2,600TWh by the mid-2000s. The nuclear share of total global electricity production reached 17% by the late 1980s, but since then has been falling and dropped to 13.5% in 2010.

There are a number of reasons for these conflicting trends. They include financial and economic developments, rapidly increasing energy demand due to population growth and social and economic development, and concerns about energy security and the environment, just to name a few.

The economic crisis of the late 2000s was a main contributing factor for delays or cancellations of nuclear projects in some regions of the world. The Swedish utility Vattenfall announced in June 2009 that it was putting decisions on nuclear new build on hold for 12–18 months, citing the economic recession and market situation. Financing uncertainty was cited in connection with the withdrawal of the utilities GDF SUEZ and RWE from the Belene project in Bulgaria. The Russian Federation announced that for the next few years, because of the financial crisis and lower projected electricity use, it would slow planned expansion from two reactors per year to one. Ontario, Canada, suspended a programme to build two replacement reactors at Darlington, partly because of uncertainty about the future of Atomic Energy of Canada Limited (AECL). The Canadian Government had reported that it planned to seek buyers for AECL to reduce budget deficits. In the USA, Exelon deferred major pre-construction work on a proposed new nuclear power plant in Texas, citing uncertainties in the domestic economy. Of 17 combined licence applications before the U.S. Nuclear Regulatory Commission (NRC), four were put on hold in 2009 at the request of the applicants. In South Africa, Eskom extended the schedule for its planned next reactor by two years to 2018.

In contrast, China saw nine construction starts in 2009 after six in 2008. It appears that as utilities elsewhere dragged their feet in following through with nuclear plant and equipment orders, China seized the opportunity, moving ahead in the queue and negotiating attractive terms. As the year 2009 drew to a close, the United Arab Emirates announced the signing of a contract to purchase four 1 400 MW_e reactors from a South Korean consortium led by the Korea Electric Power Corporation. About a dozen countries currently without nuclear power are continuing preparations to start their first nuclear power plants by the early 2020s, while an even larger number are familiarising themselves with the prerequisite nuclear infrastructure requirements.

Globally, the nuclear industry is in decline: The 427 reactors operating today are 17 reactors less than at the peak in 2002. Annual nuclear electricity generation reached a maximum of 2,660TWh in 2006, but dropped to 2,346 TWh in 2012 (down by 7% compared to 2011 and down by 12% compared to 2006). About three-quarters of this decline can be attributed to the events in Japan, but 16 other countries, including the top five nuclear generators, decreased their nuclear generation capacities, too.

Another factor impacting the global share of nuclear is the temporary unavailability of several reactors at nuclear power plants in Japan, which were shut down in July 2007 after a major earthquake. After in-depth safety inspections and seismic upgrades, two of the seven units were restarted and connected to the grid in 2009.

The “big five” nuclear generating countries:

- United States
- France
- Russia
- South Korea
- Germany

account for 67% of the total nuclear generated electricity in the world. The countries with a steady increase in nuclear generation are China, Czech Republic and Russia.

Market trends

In Europe, nuclear power phase-out policies have been scaled down in several countries. Sweden for example will now allow its existing reactors to operate to the end of their economic lifetimes and to be replaced by new reactors once they are retired. Italy ended its ban on nuclear power and might now allow new construction. Belgium decided to postpone the first phase of its planned phase-out by ten years. Closure of its reactors had been scheduled to take place between 2015 and 2025.

Fourteen countries are currently building nuclear power plants, one more than a year ago as the United Arab Emirates (UAE) started construction at Barrakah. The UAE is the first new country in 27 years to have started building a commercial nuclear power plant.

As of July 2013, 66 reactors are under construction (7 more than in July 2012) with a total capacity of 63 GW. The average construction time as of the end of 2012, was 8 years. However, nine reactors have been listed as “under construction” for more than 20 years and four additional reactors have been listed for 10 years or more. Forty-five projects do not have an official planned start-up date on the International Atomic Energy Agency’s (IAEA) database. At least 23 projects have encountered construction delays, and for the remaining 43 reactor units, either construction began within the past five years or they have not yet reached projected start-up dates, making it difficult or impossible to assess whether they are on schedule or not.

Two-thirds (44) of the units under construction are located in three countries: China, India and Russia. The average construction time of the 34 units that started up in the world between 2003 and July 2013 was 9.4 years.

Only three reactors started up in 2012, while six were shut down and in 2013 up to July, only one started up, while four shutdown decisions were taken in the first half of 2013, all of them in the US. Three of those four units faced costly repairs, while one at Kewaunee, Wisconsin was running well and had received a license renewal just two years ago to operate up to a total of 60 years. However, in the meantime, it became uneconomic to run.

Technical and economic considerations

Construction costs are a key factor for the final electricity generating costs and many current nuclear projects are significantly over budget. Cost estimates have increased in the past decade from US$1,000 to US$7,000 per kW installed.

The stock market value of the world’s largest nuclear operator, French state utility EDF, went down by 85 percent over the past five years, while the share price of the world’s largest nuclear builder, French state company AREVA, dropped by up to 88 percent.

Generally, existing operating nuclear power plants continue to be highly competitive and profitable. The low share of fuel cost in total generating costs makes them the lowest-cost base load electricity supply option in many markets. Uranium costs account for only about 5% of total generating costs and thus protect plant operators against resource price volatility.

Using a levelised cost of electricity (LCOE) calculation formula, new nuclear build is generally competitive with other generating options. The ‘front-loaded’ cost structure of nuclear plants (i.e. the fact that they are relatively expensive to build but inexpensive to operate) has always been an investment risk factor and a financial challenge, especially in competitive electricity markets.

Apart from the market related factors, there are other factors that have an impact on the development of nuclear power. On the production side, there are only a few manufacturers in the world that are capable of producing heavy forging equipment such as reactor pressure vessels or steam generators.

Another factor is carbon pricing which can improve the economics of nuclear power relative to fossil-fuelled generation.

Market trends and outlook

Each year the IAEA updates its low and high projections for global growth in nuclear power. In the updated low projection, global nuclear power capacity reaches 511 GW_e in 2030, compared to a capacity of 370 GW_e at the end of 2009. In the updated high projection it reaches 807 GW_e. The upward shift in the projections is greatest for the Far East, a region that includes China, Japan and the Republic of Korea. Modest downward shifts in the projections were made for North America and for Southeast Asia and the Pacific.

Although today the key drivers and market players defining the future of nuclear power are different from those 20-30 years ago, the emerging non-OECD economies (mainly China and India) are expected to dominate future prospects. Given that they need to use all options to meet their rapidly growing electricity demand and secure certain economic growth levels at high rates, it will constitute a major and potentially costly challenge to rule out the option of using larger shares of nuclear power.

Furthermore, these challenges will be amplified by the increasing energy price from other sources, political stability in certain energy producing markets, in addition to carbon emission and climate change concerns. The developing nations (China, Russia and India) seem to have kept most of their planned projects alive.

Despite the relatively high costs, recent accidents and growing public opposition in some regions, nuclear power is back on the agenda of many countries, primarily for following three reasons: it has predictable long-term generation costs, as it is not exposed to the volatile fossil fuels markets, and it can enhance energy security and bring along climate-change mitigation benefits. Nuclear's economic competitiveness depends on local conditions including available alternatives, market structures and government policy.

References

www.ne.doe.gov/np2010/reports/NuclIndustryStudy-Summary.pdf Accessed 10 Feb 2010.

WNA, 2009. *The Economics of Nuclear Power*, 2009, www.world-nuclear.org/info/inf02.html Accessed 3 January 2010

WNA, 2010. *WNA Nuclear Century Outlook Data*, www.world-nuclear.org/outlook/nuclear_century_outlook.html

Reserves and production

Table 1

Nuclear Energy: capacity, generation and operating experience at 1 July 2011

Source: Power Reactor Information System, International Atomic Energy Agency

	Reactors in operation		Reactors under construction		Net capacity	Nuclear share of electricity generation in 2011	Total operating experience to end-2011	
	Units	Capacity	Units	Capacity				
	number	MWe	number	MWe	TWh	%	years	months
Argentina	2	935	1	692	6	5	62	7
Armenia	1	375			3	45	35	8
Belgium	7	5 926			45	52	233	7
Brazil	2	2 007	1	1 405	16	3	37	3
Bulgaria	2	2 000			15	32	147	3
Canada	17	12 009			90	15	582	2
China	18	13 816	28	19 920	70	2	99	3
Czech Republic	6	3 970			27	33	110	10
Finland	4	2 736	1	16 00	22	26	123	4
France	59	63 130	1	1 600	368	77	1 700	2
Germany	9	12 068			102	18	751	5
Hungary	4	1 889			16	46	98	2
India	18	4 388	7	4 800	19	2	318	4
Iran (Islamic Rep.)	1	915	1	915	1	1	0	3
Japan	54	48 960	3	4 141	163	19	1 439	5
Korea (Republic)	23	20 718	3	3 600	99	30	339	8
Lithuania						76	43	6
Mexico	2	1 365			10	4	35	11
Netherlands	1	482			4	4	65	-
Pakistan	2	425	1	300	5	3	47	10
Romania	2	1 300			12	20	15	11
Russian Federation	33	23 643	9	6 500	153	18	994	4
Slovakia	4	1 816	2	810	15	54	132	7
Slovenia	1	688			6	39	28	3
South Africa	2	1 860			2	5	50	3
Spain	7	7 112			58	21	269	6
Sweden	10	9 395			61	40	372	6
Switzerland	5	3 263			26	40	173	10

Taiwan, China	6	4 949	2	2 600	40	21	170	1
Ukraine	15	13 107	2	1 900	78	49	368	6
United Kingdom	16	9 243			56	18	1 457	8
USA	104	98 903	3	1 165	799	19	3 499	9
Total World	**437**	**364 078**	**65**	**51 948**	**2 386**	**-**	**5 695**	**6**

Notes:

The capacity and output of the Krsko nuclear power plant, shown against Slovenia in the table, is shared 50/50 between Slovenia and Croatia

Total world operating experience includes reactor years for Italy and Kazakhstan which no longer operate nuclear power plants

Table 2

Nuclear fuel cycle capability

Source: NEA, 2008

	Conversion	Enrichment	Fuel fabrication	Reprocessing
Argentina	X		X	
Belgium			X	
Brazil	X		X	
Canada	X		X	
China	X	X	X	X
France	X	X	X	X
Germany		X	X	
India	X		X	X
Japan		X	X	X
Kazakhstan			X	
Korea (Republic)			X	
Netherlands		X		
Pakistan	X	X	X	
Romania			X	
Russian Federation	X	X	X	X
Spain			X	
Sweden			X	
United Kingdom	X	X	X	X
United States of America	X	X	X	

Country notes

The Country Notes on Nuclear have been compiled largely on the basis of material published in:

- *WNN Weekly,* World Nuclear Association, London;
- *WNN Weekly Digest*, World Nuclear Association, London;
- Press reports and industry web sites.

Information provided by WEC Member Committees has been incorporated when available.

Argentina

No. of reactors in operation Capacity MWe	2 935
No. of reactors under construction Capacity MWe	1 692
Net generation in 2011, TWh	6
Nuclear share of electricity generation	5%

Argentina has two nuclear reactors Atucha-I (335 MWe PHWR) and Embalse (600 MW_e PHWR) generating nearly one-tenth of the country's electricity demand. The third reactor is expected to be commissioned in 2013.

The fourth NPP, consisting of two units each of 750 MWe, is planned to be connected to the network in 2016/2017. The Member Committee foresees that by the end of 2020 four reactors will be in operation in Argentina, with an aggregate capacity of 3 232 MWe.

Armenia

No. of reactors in operation Capacity MWe	1 375
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	3
Nuclear share of electricity generation	**27%**

Armenia has relied heavily on nuclear power since 1976 when the first of the two original WWER units was commissioned. The nuclear power plant is located close to the capital Yerevan (64 km), and one of the two reactors was shut down in 1989 following an earthquake the previous year. The second of the two original WWER units (Medzamor-2) has been upgraded and refurbished, coming back into commercial operation in 1996 with a capacity of 376 MW_e. This unit supplies about a third of the total electricity produced in the country (2.4 billion kWh). Armenia has faced international pressure, especially from its neighbour Turkey, to shut down Medzamor-2 on the grounds of safety, and the government has approved a joint venture to build another plant by 2020.

Australia

No. of reactors in operation Capacity MWe	0
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	0
Nuclear share of electricity generation	**0%**

Australia has significant uranium resources and an adequate infrastructure to support any future nuclear power development. As well as the Australian Nuclear Science & Technology Organisation (ANSTO), which owns and runs the modern 20 MWt Opal research reactor, there is a world-ranking safeguards set-up - the Australian Safeguards & Non-proliferation Office (ASNO), the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) and a well-developed uranium mining industry. However, in contrast to most G20 countries, the only driver for nuclear power in Australia is reduction of CO_2 emissions, or costs arising from that. Apart from this, economic factors and energy security considerations do not make it necessary.

In December 2006 the report of the Prime Minister's expert taskforce considering nuclear power was released. It said nuclear power would be 20-50% more expensive than coal-fired power and (with renewables) it would only be competitive if "low to moderate" costs are imposed on carbon emissions (A$ 15-40 - US$ 12-30 - per tonne CO2). "Nuclear power is the least-cost low-emission technology that can provide base-load power" and has low life cycle impacts environmentally.

Bangladesh

No. of reactors in operation Capacity MWe	0
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	0
Nuclear share of electricity generation	**0%**

Bangladesh plans to have two 1000 MWe Russian nuclear power reactors in operation from 2020. This is to meet rapidly-increasing demand and reduce dependence on natural gas. Today, about 88% of electricity comes from natural gas, electricity demand is rising rapidly, with peak demand of 7.5 GWe.

Belarus

No. of reactors in operation Capacity MWe	0
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	0
Nuclear share of electricity generation	**0%**

Belarus plans to have its first nuclear power plant built with Russian finance to come into operation in 2018. Atomstroyexport has been contracted to build the 2400 MWe plant. Under its 2011-2020 energy strategy, Belarus is seeking to reduce its reliance on Russia as a major energy supplier. The plan calls for a 1000 MWe coal-fired plant and a 2400 MWe nuclear power plant as well as four hydropower stations with total capacity of 120 MW, and wind projects totaling 300 MW. Government plans to reform the electricity sector by creating a wholesale market in three stages have stalled, and electricity remains heavily subsidised for households.

The country imports 90% of its gas from Russia (estimate of 22.5 billion m^3 in 2012) - much of it for electricity, and overall aims for 25-30% energy independence, compared with half that now. The proposed 2400 MWe nuclear plant is expected to reduce gas imports by 5 billion m^3 per year, now costing over US$ 800 million, while the nuclear fuel and waste management would be a quarter of this. In November 2011 it was agreed that Russia's Gazprom would pay US$2.5 billion for the 50% of Belarus' gas transmission network, Beltransgaz, that it did not already own. This was linked both to lower gas prices and to Russian finance for the nuclear plant. Earlier, there had been studies on both a domestic nuclear power plant using Russian technology, and Belarus participation in a new nuclear unit at Smolensk or Kursk in Russia.

Belgium

No. of reactors in operation Capacity MWe	7 5 926
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	45
Nuclear share of electricity generation	**51%**

Belgium has seven nuclear reactors generating about half of its electricity. Belgium's first commercial nuclear power reactor began operation in 1974: four units at Doel and three at Tihange. they are all of the same PWR type, with a current aggregate net generating capacity of 5 863 MW_e. There has been little government support for nuclear energy, and nuclear power generation incurs a EUR 0.5 cent/kWh tax.

In January 2003, Belgium's Senate voted for a nuclear phase-out law which stipulates that all seven units shall be closed after completing 40 years of operation. The first reactors are thus due to be shut down in 2015, the last in 2025. However, the preliminary report of a study commissioned by the Federal Energy Ministry, released in November 2006, concludes that the substantial change in circumstances since the passing of the phase-out law 'requires a paradigm shift of the current official Belgian standpoint on nuclear power'. In October 2009 the Belgian Government announced that its plans for phasing out nuclear power would be put back for ten years.

Most of electricity in Belgium is produced by Electrabel, a subsidiary of GDF Suez, which also operates all the nuclear plants.

Brazil

No. of reactors in operation Capacity MWe	2 2 007
No. of reactors under construction Capacity MWe	1 1 405
Net generation in 2011, TWh	16
Nuclear share of electricity generation	**3%**

Brazil has two nuclear reactors: Angra-1 (491 MW_e net PWR) and Angra-2 (1 275 MW_e net). generating 3% of Brazil's electricity. Its first commercial nuclear power reactor began operating in 1982. Work on the construction of a third unit at Angra, of similar size to Angra-2, was started in 1983, but suspended after a few years.

Bulgaria

No. of reactors in operation Capacity MWe	2 2 000
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	15
Nuclear share of electricity generation	**32%**

Bulgaria has two nuclear reactors generating over 32% of its electricity. Originally, six WWER units have been constructed at Kozloduy, in the north-west of the country, close to the border with Romania. Four units (each of 408 MW_e net capacity) were brought into operation between 1974 and 1982, and two other (each of 953 MW_e capacity) were commissioned in 1987 and 1989, respectively.

Kozloduy-1 and -2 were shut down in December 2002, followed by Kozloduy-3 and -4 at the end of 2006, in accordance with the terms of Bulgaria's accession to the European Union.

Government's commitment to the future of nuclear energy is strong, although financing construction of new units will not be easy. Construction of a new nuclear plant was planned, but instead it was decided to add a third 1000 MWe unit to the existing plant. The country has been a significant exporter of power. However, with the closure of two older nuclear units at the end of 2006, electricity exports have dropped somewhat. Three large lignite plants supply about half the country's electricity.

Canada

No. of reactors in operation Capacity MWe	17 12 009
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	90
Nuclear share of electricity generation	**15%**

About 15% of Canada's electricity comes from nuclear power, with 17 reactors mostly in Ontario province providing 12 GWe of power capacity. Canada plans to expand its nuclear capacity over the next decade by building two more new reactors. For many years Canada has been a leader in nuclear research and technology exporting reactor systems as well as a high proportion of the world supply of radioisotopes used in medical diagnosis and cancer therapy.

Canada generated 636 billion kWh in 2011, of which about 15% was from nuclear generation, compared with 59% from hydro, 13% from coal and 8.4% from gas. According to a study by the Canadian Energy Research Institute,[1] in 2005 Canada's 18 nuclear reactors sold energy worth almost C$5billion, contributed C$6.3 billion to GDP, and created C$1.4 billion in government revenue. The nuclear power industry employed, directly and indirectly, over 66,000 people. About C$13.26 billion (in 2005 dollars) was invested by the government in Canada's nuclear program over 1952-2006 through AECL. This investment has generated more than C$160 billion in GDP benefits to Canada from power production, research and development, Candu exports, uranium, medical radioisotopes and professional services, according to AECL.

All Canadian nuclear plants are Pressurized Heavy Water Reactors (PHWR) type, using the CANDU design. The total installed nuclear capacity in Canada is approximately 14,000 MW in Ontario and New Brunswick.

China

No. of reactors in operation Capacity MWe	18 13 816
No. of reactors under construction Capacity MWe	28 19 920
Net generation in 2011, TWh	70
Nuclear share of electricity generation	**2%**

Nuclear power plays an important role in China, especially in the coastal areas located far from the coal mines and where the economy is developing rapidly. Development of nuclear power in China commenced in 1970 and about 2005 the industry moved into a rapid development phase. Technology has been drawn from France, Canada and Russia, with local development based largely on the French element. The latest technology acquisition has been from the USA (via Westinghouse, owned by Japan's Toshiba) and France. The Westinghouse AP1000 reactor is the main basis of technology development in the immediate future.

China's first NPP, Qinshan 1, a 288 MW_e PWR, was connected to the grid in December 1991 and began commercial operation in April 1994. Ten more NPPs (eight PWRs and two PHWRs) have subsequently been installed. Tianwan 2, a Russian-built 1 000 MW_e (gross) WWER, began commercial operation on 16 August 2007. Excavation of the site for the Sanmen NPP in Zhejiang province got under way in February 2008, with construction commencing officially in April 2009. Shortly afterwards it was reported that an agreement had been signed for the construction of China's first inland NPP at Xianning City, Hubei. In October 2009 it was reported that a high-level agreement had been signed with Russia for design work on two 800 MW_e fast neutron reactors for construction in China.

April 2010 witnessed a number of progress reports on China's nuclear building programme. First concrete was poured at the sites of the Taishan (Guangdong) and Changjiang (Hainan) NPPs, while fuel loading began at Unit 1 of the second phase of the Ling Ao NPP, also in Guangdong.

Czech Republic

No. of reactors in operation	6
Capacity MWe	3 970
No. of reactors under construction	0
Capacity MWe	
Net generation in 2011, TWh	27
Nuclear share of electricity generation	**33%**

The Czech Republic has six nuclear reactors generating about one-third of its electricity. The first commercial nuclear power reactor began operating in 1985. Government commitment to the future of nuclear energy is strong. Electricity generation in the Czech Republic has been growing since 1994 and in 2011, 87.6 billion kWh was generated from 20 GWe of plant, of which 57% (49.7 billion kWh) was from coal, 33% (27 billion kWh) from nuclear, with net exports of 17 billion kWh[a]. More than 80% of the country's gas comes from Russia.

A draft national energy policy to 2060 issued in 2011 indicated a major increase in nuclear power, to reach 13.9 GWe or up to 18.9 GWe in the case of major adoption of electric vehicles. It would then provide some 60% of the country's power. The version adopted in November 2012 assumed at least 50% of future generation coming from nuclear, with two new reactors being built at Temelin and one at Dukovany to take production to 46.5 TWh by 2025, and 55.2 TWh/yr later, hence further nuclear sites should be identified. The current four units at Dukovany would get 20-year life extensions, to 2045-47. Nuclear plants should supply district heating to Brno and other cities by 2030.

Finland

No. of reactors in operation	4
Capacity MWe	2 736
No. of reactors under construction	1
Capacity MWe	1 600
Net generation in 2011, TWh	22
Nuclear share of electricity generation	**26%**

Finland has four nuclear reactors providing over 30% of its electricity. Four nuclear reactors were brought into operation between 1977 and 1980: two 488 MW_e WWERs at Loviisa, east of Helsinki, and two 840 (now 860) MW_e BWRs at Olkiluoto. The construction licence for building Finland's fifth reactor, Olkiluoto 3, was granted by the Government in early 2005, subsequent to a Decision-in-Principle ratified by Parliament in 2002. The new nuclear power unit of 1 600 MW_e (net) has for a number of reasons experienced considerable delays in construction and is not expected to begin commercial operation any time soon.

In 2011 electricity production in the country was 73.5 TWh, with nuclear providing 23 TWh. Provisions for radioactive waste disposal are well advanced in Finland.

Since the 1930s energy-intensive industry has invested in large-scale energy production in Finland, rather than leaving it entirely to specialized utilities. More recently energy-intensive companies have seen joint ownership of electricity production with power sold at cost price to shareholders as an important means of protection against the increasing prices and volatility of liberalised electricity markets. This so-called Mankala model is also effective in risk-sharing. It is a distinctive of Finland in relation to capital-intensive nuclear capacity.

France

No. of reactors in operation Capacity MWe	59 63 130
No. of reactors under construction Capacity MWe	
Net generation in 2011, TWh	368
Nuclear Share of electricity generation	**77%**

France has 59 nuclear reactors operated by Electricite de France (EdF), with the total capacity of over 63 GWe supplying 368 billion kWh per year, i.e. 77% of the total generated electricity that year. About 17% of France's electricity is from recycled nuclear fuel. France has pursued a vigorous policy of nuclear power development since the mid-1970s and now has by far the largest nuclear generating capacity of any country in Europe, and is second only to the USA in the world. Apart from a single fast reactor (Phenix), PWRs account for the whole of current nuclear capacity. The present setup of the electricity industry in France is a result of the government decision in 1974, just after the first oil shock, to expand rapidly the country's nuclear power capacity using Westinghouse technology. This decision was taken in the context of France having substantial heavy engineering expertise but few indigenous energy resources. Nuclear energy, with the fuel cost being a relatively small part of the overall cost, made good sense in minimising energy imports and achieving greater energy security.

Referring to the 1974 decision and the following actions, France now claims a substantial level of energy independence and almost the lowest cost of electricity in Europe. It also has an extremely low level of CO_2 emissions per capita from electricity generation, since over 90% of its electricity is nuclear or hydro. In mid 2010 a regular energy review of France by the International Energy Agency urged the country increasingly to take a strategic role as provider of low-cost, low-carbon base-load power for the whole of Europe rather than to concentrate on the energy independence which had driven policy since 1973.

Construction of EDF's first European Pressurised Water Reactor (EPR), net capacity 1 600 MW_e) began at Flamanville (Normandie) towards the end of 2007, with completion scheduled for 2012. Work on a second EPR is planned to start at Penly in 2012.

France is the world's largest net exporter of electricity due to the very low cost of generation and it earns over 3 billion Euros per year from electricity sales abroad. France has been very active in developing nuclear technology. Reactors and fuel products and services are a major export. Currently, it is building its first Generation III reactor and planning a second.

Germany

No. of reactors in operation Capacity MWe	9 12 068
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	102
Nuclear share of electricity generation	**18%**

Germany has 9 nuclear reactors which supply almost one fifth of its electricity demand. A coalition government formed after the 1998 federal elections had the phasing out of nuclear energy as a feature of its policy. With a new government in 2009, the phase-out was cancelled, but then reintroduced in 2011, with eight reactors to shut down immediately. The cost of replacing nuclear power with renewables is estimated by the government to amount to some EUR 1000 billion. Public opinion in Germany remains negative to nuclear power and at present does not support building new nuclear plants. Germany's electricity production in 2011 was 629 billion kWh (TWh) gross with coal providing 278 TWh (45%, more than half being lignite), nuclear 108 TWh (17.5%), gas 84 TWh (13.7%), biofuels & waste 43.6 TWh (7.1%), wind 46.5 TWh (7.6%), hydro 24.6 TWh (4%), solar 19 TWh (3%). Electricity exports exceeded imports by about 4 TWh, compared with 15 TWh in 2010, but Germany remains one of the biggest importers of gas, coal and oil in the world, and has few domestic resources apart from lignite and renewables.

Germany's pioneer PWR, the 340 MW_e (net) unit at Obrigheim, was shut down on 11 May 2005 under the terms of the 2000 nuclear phase-out agreement, after 36 years of successful operation. The next reactors due for closure under the phase-out plan are three PWRs; Biblis A (net capacity 1 167 MW_e, which came into service in 1975), Biblis B (1 240 MW_e, 1977) and Neckarwestheim (785 MW_e, 1976). Many of the units are large (they total 20,339 MWe), and the last came into commercial operation in 1989. Six units are boiling water reactors (BWR), 11 are pressurised water reactors (PWR). All were built by Siemens-KWU. A further PWR had not operated since 1988 because of a licensing dispute. This picture changed in 2011, with the operating fleet being reduced to nine reactors with 12,003 MWe capacity.

Hungary

No. of reactors in operation Capacity MWe	4 1 889
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	16
Nuclear share of electricity generation	**46%**

Hungary has four nuclear reactors generating more than one-third of its electricity. Its first commercial nuclear power reactor began operating in 1982. In 2011, total electricity generation in Hungary by 9 GWe of installed capacity was 36.2 billion kWh (gross), of which nuclear's share was 15.7 billion kWh (43%). Four WWER reactors, with a current aggregate net capacity of 1 859 MW_e, came into commercial operation at Paks in central Hungary, between 1983 and 1987. The Hungarian Parliament has expressed overwhelming support for building two new power reactors.

India

No. of reactors in operation Capacity MWe	18 4 388
No. of reactors under construction Capacity MWe	7 4 800
Net generation in 2011, TWh	19
Nuclear share of electricity generation	**2%**

India has 18 reactor units in operation, with an aggregate net generating capacity of 4 388 MW_e. Sixteen are PHWRs, the other two of the BWR type: most were relatively small units, with individual capacities up to 202 MW_e; the exception is Tarapur-3 and -4, each with a net capacity of 490 MW_e. Output from India's nuclear plants accounts for about 2.2% of its net electricity generation. According to the IAEA, five reactor units were under construction at the beginning of 2010, with an aggregate net generating capacity of 2 708 MW_e. Two 202 MW_e PHWRs were under construction at end-2009: Kaiga-4 and Rajasthan-6, as well as two 917 MW_e WWERs (Kudankulam-1 and -2) and a 470 MW_e fast breeder reactor (PFBR). Rajasthan-6 was connected to the grid at the end of March 2010.

In September 2009 the Indian cabinet endorsed the reservation of two coastal sites (Mithi Virdi in Gujarat and Kovada in Andhra Pradesh) for nuclear power parks, each with up to eight reactors. Towards the end of 2009, an agreement was announced for further cooperation between Russia and India in respect of four reactors planned for Kudankulam and others at Haripur in West Bengal.

India has a flourishing and largely indigenous nuclear power programme and expects to have 14,600 MWe nuclear capacity on line by 2020. It aims to supply 25% of electricity from nuclear power by 2050. Since India is outside the Nuclear Non-Proliferation Treaty due to its weapons programme, it was for 34 years largely excluded from trade in nuclear plant or materials, which has hampered its development of civil nuclear energy until 2009. Due to these trade bans and lack of indigenous uranium, India has uniquely been developing a nuclear fuel cycle to exploit its reserves of thorium. Now, foreign technology and fuel are expected to boost India's nuclear power plans considerably. India has a vision of becoming a world leader in nuclear technology due to its expertise in fast reactors and thorium fuel cycle.

Iran (Islamic Republic)

No. of reactors in operation Capacity MWe	1 915
No. of reactors under construction Capacity MWe	1 915
Net generation in 2011, TWh	1
Nuclear share of electricity generation	**1%**

Construction of two 1 200 MW_e PWRs started at Bushehr in the mid-1970s was suspended following the 1979 revolution. In April 2006, the IAEA reported that Iran had one unit under construction: Bushehr-1 (1 000 MW_e gross, 915 MW_e net). Iran announced an international tender in April 2007 for the design and construction of two light-water reactors, each of up to 1 600 MW_e, for installation near Bushehr. The final shipment of nuclear fuel for Bushehr-1 arrived from Russia in January 2008. During February 2009, a 'pre-commission' test was carried out using 'virtual' fuel. Pre-start testing was reported to be in progress in January 2010. Commissioning tests continued during March. On 21 August the process of loading nuclear fuel into the first unit at Bushehr began under the supervision of inspectors from the IAEA.

A large nuclear power plant Bishehr-1 has started up in Iran, after many years construction, and it has been grid-connected. The country also has a major program developing uranium enrichment which was concealed for many years. Iran has not suspended its enrichment-related activities, or its work on heavy water-related projects, as required by the UN Security Council.

Italy

No. of reactors in operation Capacity MWe	0
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	0
Nuclear share of electricity generation	**0%**

Italy has had four operating nuclear power reactors but shut the last two down following the Chernobyl accident. Some 10% of its electricity comes today from nuclear power – all imported, however. The government intended to have 25% of electricity supplied by nuclear power by 2030, but this prospect was rejected at a referendum in June 2011.

Italy is the only G8 country without its own nuclear power plants, having closed its last reactors in 1990. In 2008, government policy towards nuclear changed and a substantial new nuclear build programme was planned. However, in a June 2011 referendum the 2009 legislation setting up arrangements to generate 25% of the country's electricity from nuclear power by 2030 was rejected.

Japan

No. of reactors in operation Capacity MWe	54 48 960
No. of reactors under construction Capacity MWe	3 4 141
Net generation in 2011, TWh	163
Nuclear share of electricity generation	**19%**

Japan has to import about 81% of its energy requirement. Its first commercial nuclear power reactor began operating in 1966, and nuclear energy has been a national strategic priority since 1973. This is now under review following the 2011 Fukushima accident. The country's 50 main reactors have produced about 30% of electricity and this share was expected to increase to at least 40% by 2017. The current estimate is for about half of this. Japan has a full fuel cycle set-up, including enrichment and reprocessing of used fuel for recycling.

Despite being the only country to have suffered the devastating effects of nuclear weapons in wartime, with over 100,000 deaths, Japan embraced the peaceful use of nuclear technology to provide a substantial portion of its electricity. However, following the tsunami which killed 19,000 people and which triggered the Fukushima nuclear accident, public sentiment shifted markedly and there were public protests calling for nuclear power to be abandoned. The balance between this populist sentiment and the continuation of reliable and affordable electricity supplies is being worked out politically.

According to IAEA data, there were 55 operable nuclear reactors at the end of 2008, with an aggregate generating capacity of 49 315 MW_e gross, 47 278 MW_e net. Within this total there were 28 BWRs (24 764 MW_e gross, 23 908 MW_e net), 23 PWRs (19 366 MW_e gross, 18 420 MW_e net) and four ABWRs (5 185 MW_e gross, 4 950 MW_e net). Tomari-3, an 866 MW_e (net) PWR entered commercial service on 22 December 2009. At the beginning of 2010, total net nuclear generating capacity was 46 823 MW_e in 54 reactors, which provided about 29% of Japan's net generation of electricity during the year. One reactor, Shimane-3 (a 1 325 MW_e ABWR) was under construction.

Jordan

No. of reactors in operation Capacity MWe	0
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	0
Nuclear share of electricity generation	**0%**

Jordan imports over 95% of its energy needs, at a cost of about one fifth of its GDP. It generates 14.3 billion kWh, mostly from natural gas, and imports 0.4 billion kWh of electricity for its six million people. Jordan is looking for ways to reinforce its energy security and at the same time keep lower electricity prices. Jordan is expected to start building a 750-1200 MWe nuclear power unit in 2013 to be commissioned by 2020 and a second unit for operation by 2025.

Kazakhstan

No. of reactors in operation Capacity MWe	0
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	0
Nuclear share of electricity generation	**0%**

Kazakhstan has 15% of the world's uranium resources and has been an important source of uranium for more than fifty years. Over 2001-2011 production rose from 2,022 to 19,450 tonnes U per year, thus making Kazakhstan the world's leading uranium producer. Mine development has continued with a view to further increasing annual production by 2018. The current capacity is around 25,000 tU/yr, but in October 2011 Kazatoprom announced a cap on production at 20,000 tU/yr. Of its 17 mine projects, 5 are wholly owned by Kazatomprom and 12 are joint ventures with foreign equity holders. A single Russian nuclear power reactor operated from 1972 to 1999, generating electricity for desalination .Kazakhstan has a major plant making nuclear fuel pellets and aims eventually to sell value-added fuel rather than just uranium. It aims to supply 30% of the world fuel fabrication market by 2015.

The government is committed to increased uranium exports, and is considering future options for nuclear power. The only NPP to have operated in Kazakhstan was BN-350, a 70 MW_e fast breeder reactor located at Aktau on the Mangyshlak Peninsula in the Caspian Sea. It came into service in 1973 and was eventually shut down in June 1999. Reflecting its small generating capacity, and its additional use for desalination and the provision of process heat, BN-350's contribution to the republic's electricity supply was minimal: over its lifetime of operation, its average annual output was only about 70 GWh.

A government plan to install two small VBER-300 nuclear reactors by 2015-2016 was announced in November 2007. The first was expected to be sited at Aktau, where the country's previous NPP was located.

The WEC Member Committee for Kazakhstan considers that, in local conditions, large-capacity NPPs are not appropriate: a preferred direction for power industry development would be the establishment of a regional power industry based on commercially available, reliable and safe NPPs with a capacity in the range of 100-300 MW_e. The Committee expects that reactors of this size would find a ready market in the region, as they would optimally comply with long-term development and power supply needs, and provide a perfect match with the capacity range of the fossil-fuel power plants that will in due course need to be replaced as a result of resource depletion. The joint-venture project for the VBER-300 reactor at Aktau benefits from Kazakhstan and Russia's many years' experience in designing, manufacturing and maintaining marine nuclear installations (ships and submarines) and modern NPPs.

Korea (Democratic People's Republic)

No. of reactors in operation Capacity MWe	0
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	0
Nuclear share of electricity generation	**0%**

A project for the construction of a 1 040 MW_e PWR was initiated in 1994 by the Korean Peninsula Energy Development Organisation (KEDO), funded by the USA, the Republic of Korea, Japan and the EU. It was suspended in 2002 and finally abandoned in June 2006.

Korea (Republic)

Korea has 23 nuclear reactors (19 PWRs and 4 PHWRs) in operation, with a reported aggregate net capacity of 20 7180 MW_e. Nuclear power makes a substantial contribution to Korea's energy supply, providing 30% of its electricity in 2011.

Three more reactors were under construction at the end of 2011. Previously the WEC Member Committee for the Korea Republic had reported that the National Energy Committee has announced 'The 1st National Energy Basic Plan', which defines the long-term strategy for the Korean energy industry over the coming twenty years and stresses the importance of nuclear power. By 2030, nuclear power will account for 41% of total generating plants and 59% of overall generating capacity. The Government is encouraging strategic partnerships and the development of next-generation reactors, in order to foster the growth of nuclear power as an export industry.

Following the sale of four NPPs to the UAE at the end of 2009, the Republic of Korea's Ministry of Knowledge Economy declared that its aim was to promote the export of 80 NPPs worth US$400 billion by 2030, and for the country to become the world's third largest supplier of power reactors.

No. of reactors in operation Capacity MWe	23 20 718
No. of reactors under construction Capacity MWe	3 3 600
Net generation in 2011, TWh	99
Nuclear share of electricity generation	**30%**

Lithuania

No. of reactors in operation Capacity MWe	0
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	0
Nuclear share of electricity generation	**0%**

Lithuania shut down its last nuclear reactor, which had been generating 70% of its electricity, at the end of 2009. Until then electricity was a major export for Lithuania. A new nuclear plant is planned to be built by GE Hitachi, based on a financial arrangement using vendor equity with participation of the other Baltic states. However, a 2012 referendum has introduced some uncertainty into these plans.

During the last year of two reactors being online, the country's nuclear industry produced 13.9 billion kWh out of a total 19.3 billion kWh. In the northeast of the country, Lithuania hosted the two largest Russian reactors of the RBMK type. These Ignalina reactors were originally 1500 MWe units (1380 MWe net), but were later de-rated to 1300 MWe (1185 MWe net). One of them came online at the end of 1983 (unit 1) and the second reactor was commissioned in 1987 (unit 2), with a 30-year design life. Lithuania assumed ownership of them in 1991 after the collapse of the Soviet Union. They are light-water, graphite-moderated types, similar to those at Chernobyl in the Ukraine. Construction on a third reactor at Ignalina commenced in 1985 but was suspended after the 1986 Chernobyl accident, and the unit was later demolished.

The National Energy Strategy approved by the Seimas in 2007 states that taking into consideration energy security issues and the possibility of using the existing infrastructure at Ignalina, new NPP capacity will be commissioned in Lithuania. Construction of the new plant would avoid heavy dependence on imports of fossil fuels, reduce pollution and possibly mitigate related economic consequences. Currently it is planned to commission the new unit in 2019. It is expected that decisions on the particular type of technology to be employed and the capacity of the NPP and its units, as well as on a timetable for project implementation, will be made in the near future.

The Ministry of Environment gave its approval in May 2009 to plans to build an NPP of up to 3 400 MWe capacity at Visaginas, close to Lithuania's borders with Latvia and Belarus.

Mexico

No. of reactors in operation Capacity MWe	2 1 365
No. of reactors under construction Capacity MWe	
Net generation in 2011, TWh	10
Nuclear share of electricity generation	**4%**

Mexico has two nuclear reactors which generate almost 4% of its electricity. Its first commercial nuclear power reactor began operating in 1989. There is some government support for expanding nuclear energy to reduce reliance on natural gas, but recent low gas prices have made this less of a priority.

Mexico is rich in hydrocarbon resources and is a net energy exporter. The country's interest in nuclear energy is rooted in the need to reduce its reliance on these sources of energy. In the next few years Mexico will increasingly rely on natural gas, and this is central in the new 2012 energy policy. The Federal Electricity Commission (CFE) planned to invest US$4.9 billion in 2011 andUS$6.7 billion in 2012 in new gas-fired plant and converting coal plants to gas. In addition it is calling for tenders to build three major natural gas pipelines.

There is a single nuclear power station with two BWR units of total net capacity 1 300 MW_e, located at Laguna Verde in the eastern state of Veracruz. The first unit was brought into operation in April 1989 and the second in November 1994. Laguna Verde's electricity output accounts for 4.8% of Mexico's total net generation. A major retrofit project for Laguna Verde was announced in March 2007; when completed in 2010, the capacity of each unit will have been increased by 20% to about 785 MW_e.

Of total 62 GWe capacity in 2010, nuclear was 1.37 GWe (gross), hydro 11.2 GWe, geothermal 970 MWe and the balance fossil fuels. Capacity is projected to increase to 86 GWe by 2025.

Netherlands

No. of reactors in operation Capacity MWe	1 482
No. of reactors under construction Capacity MWe	
Net generation in 2011, TWh	4
Nuclear share of electricity generation	**4%**

Nuclear power has a small role in the Dutch electricity supply, with the Borssele reactor providing about 4% of total generation - 4.1 billion kWh in 2011. It began operating in 1973. Initially, two NPPs have been constructed in the Netherlands: a 55 MW_e BWR at Dodewaard (which operated from 1968 to 1997) and a 449 MW_e PWR at Borssele (on line from 1973). Borssele's output accounts for 3.7% of Dutch electricity generation. In January 2006 the Dutch Government agreed to a 20-year life extension for the Borssele plant, allowing it to operate until December 2033; six months later Parliament ratified the decision. Also in June 2006, the chairman and CEO of Delta, one of the companies with shareholdings in Borssele's operator EPZ, revealed that Delta was investigating the possibility of constructing a new reactor at Borssele, which could be operating by 2016. A major refit completed at the end of 2006 resulted in Borssele's capacity being raised to 482 MW_e.

September 2006 saw a reversal of the Government's phase-out policy, when new conditions for the construction of NPPs were announced. Any new reactor must be a third-generation model, with barriers to prevent containment breaches. Other rules relate to the disposal of high-level waste and used fuel, plant dismantling and decommissioning funds.

In June 2009 the Dutch utility Delta began a process designed to lead to an application to build an NPP, to be operating by 2018. Public and political support is increasing for expanding nuclear energy.

Nigeria

No. of reactors in operation Capacity MWe	0
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	0
Nuclear share of electricity generation	**0%**

The Federal Government has approved the technical framework for fast-tracking the deployment of NPPs in Nigeria. The country's nuclear roadmap envisages the installation of 1 000 MW_e by 2017 and 4 000 MW_e by 2027.

In March 2009 Russia and Nigeria agreed to cooperate on the peaceful use of nuclear energy, including the construction of NPPs.

Pakistan

No. of reactors in operation Capacity MWe	2 425
No. of reactors under construction Capacity MWe	1 300
Net generation in 2011, TWh	5
Nuclear share of electricity generation	**5%**

Pakistan has a small nuclear power programme, with 725 MWe capacity, but plans to increase this substantially. Pakistan's nuclear weapons capabilities have been developed independently of the civil nuclear fuel cycle using indigenous uranium. Since Pakistan is outside the Nuclear Non-Proliferation Treaty, due to its weapons programme, it is largely excluded from trade in nuclear plant or materials, which hinders its development of civil nuclear energy.

In 2010 Pakistan produced 94.5 billion kWh of electricity, 33 TWh of this from oil, 26 from natural gas and 32 from hydro. Nuclear power makes a small contribution to total electricity production supplying only 5.2 TWh (5% of the electricity in 2011). In 2005 an Energy Security Plan was adopted by the government, calling for a huge increase in generating capacity to more than 160 GWe by 2030. Significant power shortages are reported, and load shedding is common.

Philippines

No. of reactors in operation Capacity MWe	
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	0
Nuclear share of electricity generation	**0%**

After a government decision in 2007 to re-examine the scope for using nuclear power in the Philippines, the feasibility of rehabilitating the mothballed Bataan NPP was examined by an IAEA team early in the following year. The Korean Republic has reportedly also offered assistance.

Poland

No. of reactors in operation Capacity MWe	0
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	0
Nuclear share of electricity generation	**0%**

Poland plans to have nuclear power from about 2025 as part of its energy portfolio diversification, moving it away from heavy dependence on coal and imported gas. The nuclear plant will be a joint venture of three utilities and a copper mine all state-owned. It was earlier planned to have a stake in the new Visaginas nuclear power plant in Lithuania.

In 2011, Poland produced some 163 billion kWh gross from 33 GWe installed capacity of mostly coal plant. Coal provided 141 TWh (86.5%) of the electricity, gas 5.8 TWh (3.5%), biofuels 7.9 TWh (4.8%) and wind 2.7 TWh (1.6%). Net exports were 1.4 billion kWh.

Romania

No. of reactors in operation Capacity MWe	2 1 300
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	12
Nuclear share of electricity generation	**20%**

Romania has two nuclear reactors generating almost 20% of its electricity. The first commercial nuclear power reactor began operation in 1996. Its second started up in May 2007. Plans are well advanced for completing two more units, but finance has not been arranged. Romanian government support for nuclear energy is strong. Nuclear energy now provides 10% of the electricity at very low cost, only hydro (29% of supply) is cheaper. In 2006, 40% of electricity was generated from coal, 19% from gas, 29% from hydro and 9% from nuclear. In 2007 13% was from nuclear, with unit 2 of Cernavoda coming on line.

Romania's first nuclear plant - a PHWR supplied by AECL of Canada, with a current net capacity of 655 MW_e - came on line in 1996 at Cernavoda in the east of the republic. Cernavoda-2 entered commercial service in October 2007, having achieved grid connection on 7 August. The Cernavoda NPP was designed for five reactors, using Canadian CANDU-type technology. While completion of the third and fourth units is being planned, there appear to be no plans to construct the fifth unit.

In February 2010 it was announced that the Romanian power company EnergoNuclear and AECL had signed a contract for the Canadian company to assess the technical and commercial viability, and planning of Cernovada-3 and -4, in order to define what is required to complete the project.

Russian Federation

No. of reactors in operation Capacity MWe	33 23 643
No. of reactors under construction Capacity MWe	9 6 500
Net generation in 2011, TWh	166
Nuclear share of electricity generation	**18%**

Russia is moving steadily forward with plans for a much expanded role for nuclear energy, with 50% increase in output by 2020. Efficiency of nuclear generation in Russia has increased dramatically since the mid-1990s. Exports of nuclear goods and services are a major Russian policy and economic objective. Technologically, Russian reactor designs are well advanced and the country is a world leader in fast neutron reactor technology.

Russia's first nuclear power plant, and the first in the world to produce electricity, was the 5 MWe Obninsk reactor, in 1954. Russia's first two commercial-scale nuclear power plants started up in 1963-64, then in 1971-73 the first of today's production models were commissioned. By the mid 1980s Russia had 25 power reactors in operation, but the nuclear industry was beset by problems. The Chernobyl accident led to a resolution of these.

There are 33 nuclear units installed at ten different sites at the end of 2009, with an aggregate net generating capacity of 21 743 MW_e. The reactor types represented consisted of eleven 925 MW_e LWGRs, nine 950 MW_e WWEfour 411 MW_e WWERs, four 11 MW_e LWGRs, two 385 MW_e WWERs and one 560 MW_e FBR. In all, NPPs provided almost 18% of the Russian Federation's electricity output in 2009.

Site licences were issued in November 2009 for the Seversk nuclear co-generation plant in the Tomsk Oblast, Siberia. The containment dome at Kalinin 4 was installed in December 2009. It was reported in March 2010 that Volgodonsk 2, near Rostov, had been synchronised with the regional power grid and would enter commercial operation later in the year.

Rosenergoatom is the only Russian utility operating nuclear power plants. Its ten nuclear plants have the status of branches. It was established in 1992 and was reconstituted as a utility in 2001.

In February 2010 the government approved the federal target program designed to bring a new technology platform for the nuclear power industry based on fast reactors. Rosatom's long-term strategy up to 2050 involves moving Jto inherently safe nuclear plants using fast reactors with a closed fuel cycle. It envisages nuclear providing 45-50% of electricity at that time, with the share rising to 70-80% by the end of the century. In June 2010 the government approved plans for 173 GWe of new generating capacity by 2030, 43.4 GWe of this being nuclear.

Slovakia

No. of reactors in operation Capacity MWe	4 1 816
No. of reactors under construction Capacity MWe	2
Net generation in 2011, TWh	15
Nuclear share of electricity generation	**54%**

Slovakia has four nuclear reactors generating half of its electricity and two more under construction. Slovakia's first commercial nuclear power reactor began operating in 1972. Government commitment to the future of nuclear energy is strong.

Electricity consumption in Slovakia has been fairly steady since 1990[a]. Generating capacity in 2010 was 7.9 GWe, almost one quarter of this nuclear[b]. In 2011, 26 billion kWh gross was produced, 15.4 TWh (55%) of this from nuclear power, with hydro 4.1 TWh (16%), coal 4.1 TWh (16%) and gas 2.2 TWh (8.5%) also. Net imports were 0.7 TWh. Slovakia has gone from being a net exporter of electricity – of some 1 billion kWh/yr – to being a net importer following the shutdown of the Bohunice V1 reactors[c].

Bohunice-1 reactor (408 MW_e) was shut down on 31 December 2006, in accordance with the terms of Slovakia's accession to the European Union on 1 May 2004. Bohunice-2 was withdrawn from service at the end of 2008. The remaining four reactors are reported to have a current net capacity of 1 711 MW_e and to have provided 53.5% of the republic's electricity output in 2009.

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Slovenia

No. of reactors in operation Capacity MWe	1 688
No. of reactors under construction Capacity MWe	
Net generation in 2011, TWh	1
Nuclear share of electricity generation	**38.5%**

Slovenia has shared a nuclear power reactor with Croatia since 1981. A bi-national PWR (current capacity 666 MW_e net) has been in operation at Krsko, near the border with Croatia since 1981. Krsko's output, which is shared 50/50 with Croatia, accounted for 37.8% of Slovenia's net electricity generation in 2009. According to the Slovenian WEC Member Committee Krsko will operate till 2023, with possible extension.

Electricity production in Slovenia in 2011 was 16.1 billion kWh gross, and after net exports of 1.3 billion kWh, final consumption was 12 billion kWh. Nuclear power from the single reactor supplied 6.2 TWh (38.5%) of the country's electricity in 2011, coal provided 5.3 TWh (33%) and hydro 3.7 TWh (23%). NPP Krsko supplied a record 5.8 billion kWh in 2008, split equally between Slovenia and Croatia.

South Africa

No. of reactors in operation Capacity MWe	2 1 860
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	2
Nuclear share of electricity generation	**5%**

South Africa has two nuclear reactors generating 5% of its electricity. South Africa's first commercial nuclear power reactor began operating in 1984. Government commitment to the future of nuclear energy is strong, with firm plans for further 9600 MWe in the next decade, but financial constraints are severe. Construction of a demonstration Pebble Bed Modular Reactor has been cancelled.

In 2008, Eskom power stations produced 230.0 billion kWh (TWh) of electricity (out of total South African electricity production of 239.5 TWh), of which the Koeberg nuclear plant generated 12.7 TWh – about 5.3% of total South African generation.

There is a single nuclear power station at Koeberg, about 40 km north of Cape Town. The plant has two 900 MW_e PWR units which were commissioned in 1984-1985. The plant, which is owned and operated by Eskom, the national utility, provided nearly 5% of South Africa's electricity in 2009. Nuclear fuel is procured and delivered to the Koeberg NPP in accordance with government-authorised contracts for the supply of enriched uranium and for the supply of fabrication services for the nuclear fuel assemblies. Development of the pebble bed modular reactor (PBMR) concept, which is based on a number of small reactors operating in tandem, has been undertaken in South Africa for a number of years, but now appears to be in jeopardy.

In the May 2011 budget speech the energy minister reaffirmed that 22% of new generating capacity by 2030 would be nuclear and 14% coal-fired. The budget also provided R586 million ($85 million) for the Nuclear Energy Corporation of South Africa (NECSA) "to continue with its central role as the anchor for nuclear energy research and development and innovation."

Spain

No. of reactors in operation Capacity MWe	7 7 112
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	58
Nuclear share of electricity generation	**21%**

Spain has seven nuclear reactors generating a fifth of its electricity. Its first commercial nuclear power reactor began operating in 1968. There are plans for renewed uranium mining. Government commitment to the future of nuclear energy in Spain has been uncertain, but has firmed up as the cost of subsidising renewables becomes unaffordable.

Nine nuclear reactors were brought into commission between 1968 and 1988. José Cabrera-1 (Zorita-1), Spain's oldest NPP (142 MW_e), was permanently shut down on 30 April 2006 after 38 years in operation. It had previously been scheduled for closure in 2008, but in 2004 the Government decided to close it two years earlier.The remaining eight reactors had an aggregate net capacity of 7 450 MW_e and in that year provided 17.5% of Spain's electricity generation. Two of the units are BWRs (total capacity 1 510 MW_e), the rest being PWRs. The Garoña NPP (a 446 MW_e BWR) was granted a four-year life extension in July 2009.

Sweden

No. of reactors in operation Capacity MWe	10 9 395
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	61
Nuclear share of electricity generation	**40%**

Between 1971 and 1985 a total of 12 nuclear reactors (nine BWRs and three PWRs) commenced operation. The 10 units remaining in service at end-2009 had an aggregate net capacity of 8 958 MW_e. Nuclear power provided 42% of Sweden's net output of electricity in 2008, but its share fell to 37.4% the following year.

Sweden's coalition government annulled the country's anti-nuclear policies early in 2009. In May of the same year approval was given for increasing the thermal output of Ringhals 3 by 5%, and test operation of the uprated unit for one year was sanctioned in the following October.

It was announced in June 2009 that the world's first permanent disposal site for used nuclear fuel would be constructed at Forsmark in eastern Sweden, with site works possibly beginning in 2013.

A capacity expansion of almost 38% for Unit 2 of the Oskarshamn NPP received government approval in April 2010.

Sweden's nuclear capacity at end-2020 is forecast by the WEC Member Committee to total 10 000 MW_e from 10 units, implying that an overall increase of around 1 062 MW_e (or 11.9%) is obtained as a result of uprating existing reactors during the years 2009-2020, assuming that no new reactors are brought into service in this period.

Switzerland

No. of reactors in operation Capacity MWe	5 3 263
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	26
Nuclear share of electricity generation	**40%**

Switzerland has 5 nuclear reactors generating 40% of its electricity. Two large new units were planned. A national vote had confirmed nuclear energy as part of Switzerland's electricity mix. However, in June 2011 parliament resolved not to replace any reactors, and hence to phase out nuclear power by 2034.

In 2011 electricity production was 64.5 billion kWh gross, mostly from nuclear and hydro. A lot of electricity is imported from France, Austria and Germany and up to 26 TWh/yr exported to Italy, with exports and imports largely balanced. In 2011 nuclear power contributed 25.6 TWh, 40.6% of Swiss total production, with hydro supplying 53%.

The Swiss WEC Member Committee reports that decommissioning of the three oldest NPPs, Beznau I and II and Mühleberg, with a combined capacity of 1 085 MW_e (one-third of the country's total nuclear capacity) is expected around 2020. Furthermore, drawing rights for some 2 500 MW_e of French nuclear capacity will gradually expire in the second half of the next decade. Replacement of this capacity will provide a major challenge for Swiss energy policy in the coming years.

Three general licence applications for new NPPs (at the existing sites of Beznau, Gösgen and Mühleberg) have been filed by the three main Swiss utilities. The Nuclear Energy Law of 2005 requires general licences for NPPs to be voted by Parliament. Under Swiss legislation, parliamentary decisions can be challenged in a popular referendum. Public opinion is currently split into two equal camps of pros and cons. Opponents have announced that they would launch a referendum against any parliamentary approval of general NPP licences. This is expected to occur around 2013/14. Meanwhile, efforts are under way to form a consortium among the utilities so as to reduce the licence applications to two, since three applications slow down licensing procedures and mobilise opposition, given that the country will need only one or possibly two NPPs in the future.

Turkey

No. of reactors in operation Capacity MWe	0
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	0
Nuclear share of electricity generation	**0%**

Turkey has had plans for establishing nuclear power generation since 1970. Today, plans for nuclear power are a key aspect of the country's aim for economic growth. Recent developments have seen Russia take a leading role in offering to finance and build 4800 MWe of nuclear capacity. Application has been made for construction and operating licences for the first plant, at Akkuyu, and these are expected in mid 2014. A Franco-Japanese consortium is to build the second nuclear plant, at Sinop. Turkey imports much of its energy, and in 2012 this amounted to more than $60 billion. Improving energy efficiency and energy security are high priorities.

Plans for nuclear power are a key aspect of the country's aim for economic growth, and it aims to cut back its vulnerable reliance on Russian and Iranian gas for electricity. The Ministry of Energy and Natural Resources (ETKB) projects 2020 electricity production as possibly 499 TWh in a high scenario of 8% growth, or 406 TWh with a low one with 6.1% growth.

Ukraine

No. of reactors in operation Capacity MWe	15 13 107
No. of reactors under construction Capacity MWe	2 1 900
Net generation in 2011, TWh	78
Nuclear share of electricity generation	**49%**

Ukraine is heavily dependent on nuclear energy - it has 15 reactors generating about half of its electricity. Ukraine receives most of its nuclear services and nuclear fuel from Russia. In 2004 Ukraine commissioned two large new reactors. The government plans to maintain nuclear share in electricity production to 2030, which will involve substantial new build.

A large share of primary energy supply in Ukraine comes from the country's uranium and substantial coal resources. The remainder is oil and gas, mostly imported from Russia.
In 1991, due to breakdown of the Soviet Union, the country's economy collapsed and its electricity consumption declined dramatically from 296 billion kWh in 1990 to 170 in 2000, the decrease coming mainly from coal and gas plants. Today Ukraine is developing shale gas deposits and hoping to export this to western Europe by 2020 through the established pipeline infrastructure crossing its territory from the east.

A major increase in electricity demand to 307 billion kWh per year by 2020 and 420 billion kWh by 2030 is envisaged, and government policy was to continue supplying half of this from nuclear power. This would have required 29.5 GWe of nuclear capacity in 2030, up from 13.9 GWe (13.2 GWe net) now.

In mid 2011 the Ukraine energy strategy to 2030 was updated, and in the electricity sector nuclear power's role was emphasized, with improved safety and increased domestic fuel fabrication. In mid 2012 the policy was gain updated, and 5000 to 7000 MWe of new nuclear capacity was proposed by 2030, costing some US$25 billion.

Four 925 MW_e RBMK reactors were installed at Chernobyl between 1977 and 1983. In April 1986 the last unit to be completed (Chernobyl-4) was destroyed in the world's worst nuclear accident. Chernobyl-2 was closed down in 1991, Chernobyl-1 in 1996 and Chernobyl-3 in December 2000.

United Arab Emirates

No. of reactors in operation Capacity MWe	0
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	0
Nuclear share of electricity generation	**0%**

The UAE is taking deliberate steps in close consultation with the International Atomic Energy Agency to embark upon a nuclear power programme. It accepted a $20 billion bid from a South Korean consortium to build four commercial nuclear power reactors, total 5.6 GWe, by 2020. Construction of the first unit started in July 2012.

In April 2008 the Government of the UAE published a comprehensive national policy on nuclear energy, which envisaged the eventual installation of a series of NPPs in the Emirates. In May of the following year President Obama approved a nuclear energy cooperation agreement between the USA and the UAE. By October the latter had established a national nuclear regulatory authority, whilst at the end of the year it was reported that the UAE had selected Korean Republic companies to lead the construction of four APR1400 reactors. In April 2010, the preferred site of the first NPP to be constructed in the Emirates was reported to be Braka, 53 km west of Ruwais. Construction is planned to begin in late 2012, with commercial operation of the first two units envisaged for 2017-2018, followed by units 3 and 4 in 2019-2020.

United Kingdom

No. of reactors in operation Capacity MWe	16 9 243
No. of reactors under construction Capacity MWe	0
Net generation in 2011, TWh	56
Nuclear share of electricity generation	**18%**

The UK has 16 reactors generating about 19% of its electricity and all but one of these are due to be retired by 2023. EDF intends to build four new EPR reactors (each of around 1.6 GW_e) by 2025, with the first one operational by the end of 2017. RWE and E.ON have announced a joint venture with an objective of delivering at least 6 GW_e of new NPPs, with the first station coming on line at around the end of the next decade.

The country has full fuel cycle facilities including major reprocessing plants. The UK has implemented a very thorough assessment process for new reactor designs and their siting.The first of some 19 GWe of new-generation plants are expected to be on line about 2018. The government aims to have 16 GWe of new nuclear capacity on line by 2030.

In the late 1990s, nuclear power plants contributed around 25% of total annual electricity generation in the UK, but this has gradually declined as old plants have been shut down and ageing-related problems affect plant availability. Net electricity imports from France – mostly nuclear – in 2011 were 6.2 billion kWh, less than 2% of overall supply.

The Government is currently preparing a draft National Policy Statement for nuclear power. This will set out the national need for new nuclear power, and include a draft list of sites that the Government has judged to be potentially suitable for the deployment of new NPPs by the end of 2025. Subject to public consultation and Parliamentary scrutiny, the National Policy Statement would be used by the new Infrastructure Planning Commission when it makes decisions on applications for development consent for new NPPs.

The Government expects the first new nuclear power station to be operational from around 2018.

United States of America

No. of reactors in operation Capacity MWe	100 98 903
No. of reactors under construction Capacity MWe	3 1 165
Net generation in 2011, TWh	799
Nuclear share of electricity generation	**19%**

The USA is the world's largest producer of nuclear power, accounting for more than 30% of worldwide nuclear generation of electricity. The country's 104 nuclear reactors produced 821 billion kWh in 2011, over 19% of total electrical output. There are now 103 units operable and three under construction. Following a 30-year period in which few new reactors were built, it is expected that 4-6 new units may come on line by 2020, the first of those resulting from 16 licence applications made since mid-2007 to build 24 new nuclear reactors. However, lower gas prices since 2009 have put the economic viability of some of these projects in doubt.

Government policy changes since the late 1990s have helped pave the way for significant growth in nuclear capacity. Government and industry are working closely on expedited approval for construction and new plant designs.

The USA has 103 nuclear power reactors in 31 states, operated by 30 different power companies. Since 2001 these plants have achieved an average capacity factor of over 90%, generating up to 807 billion kWh per year and accounting for 20% of total electricity generated. Capacity factor has risen from 50% in the early 1970s, to 70% in 1991, and it passed 90% in 2002, remaining at around this level since. The industry invests about $7.5 billion per year in maintenance and upgrades of these reactors.

There are 68 pressurized water reactors (PWRs) with combined capacity of about 66 GWe and 35 boiling water reactors (BWRs) with combined capacity of about 34 GWe – for a total capacity of 101,355 MWe (see Nuclear Power in the USA Appendix 1: US Operating Nuclear Reactors). Almost all the US nuclear generating capacity comes from reactors built between 1967 and 1990. There have been no new construction starts since 1977, largely because for a number of years gas generation was considered more economically attractive and because construction schedules were frequently extended by opposition, compounded by heightened safety fears following the Three Mile Island accident in 1979. A further PWR – Watts Bar 2 – is expected to start up in 2015 following Tennessee Valley Authority's (TVA's) decision in 2007 to complete the construction of the unit.