"such an illuminating report"
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Deputy Editor,
China Dialogue,
London, UK

"must reading for any observer of nuclear energy"
Henry Sokolski
Executive Director,
Nonproliferation Policy
Education Center (NPEC),
Washington, USA

"the quality of your information is impeccable"
Alain Michel
Former nuclear industry official,
Publisher, *Le Hêtre Pourpre*,
Namur, Belgium

The World Nuclear Industry Status Report 2007

Extended Summary

by

Mycle Schneider, Paris

with contributions from

Antony Froggatt, London

Independent Consultants

Brussels, January 2008

Commissioned by the Greens-EFA Group in the European Parliament

The Greens | European Free Alliance
in the European Parliament

Note: The full report can be downloaded from the website of the Greens-EFA Group in the European Parliament at:

http://www.greens-efa.org/cms/topics/dokbin/206/206749.the_world_nuclear_industry_status_report@en.pdf

For questions and comments please contact:

Michel Raquet
Energy Adviser
Greens / EFA
European Parliament
PHS 06C69
Rue Wiertzstraat
B-1047 Brussels
Phone: +32.2.284.23.58
E-mail: mraquet@europarl.eu.int
Web: www.greens-efa.org

To contact the authors:

Mycle Schneider Consulting
45, Allée des deux cèdres
91210 Draveil (Paris)
France
Skype: mycleschneider
Phone: +33-1-69 83 23 79
Fax: +33-1-69 40 98 75
E-mail: mycle@orange.fr

Antony Froggatt
53a Nevill Road
N16 8SW London
UK
Skype: antonyfroggatt
Phone: +44-207-923 04 12
Fax: +44-207-923 73 83
E-mail: a.froggatt@btinternet.com

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The Authors

Mycle Schneider works as independent international consultant on energy and nuclear policy.
He founded the Energy Information Agency WISE-Paris in 1983 and directed it until 2003. Since 1997 Mycle has provided information and consulting services to the Belgian Energy Minister, the French and German Environment Ministries, the International Atomic Energy Agency, Greenpeace, the International Physicians for the Prevention of Nuclear War, the Worldwide Fund for Nature, the European Commission, the European Parliament's Scientific and Technological Option Assessment Panel and its General Directorate for Research, the Oxford Research Group, and the French Institute for Radiation Protection and Nuclear Safety. Since 2004 he has been in charge of the Environment and Energy Strategies lecture series for the International MSc in Project Management for Environmental and Energy Engineering Program at the French Ecole des Mines in Nantes.
In 1997, along with Japan's Jinzaburo Takagi, he received the Right Livelihood Award, also known as the "Alternative Nobel Prize".

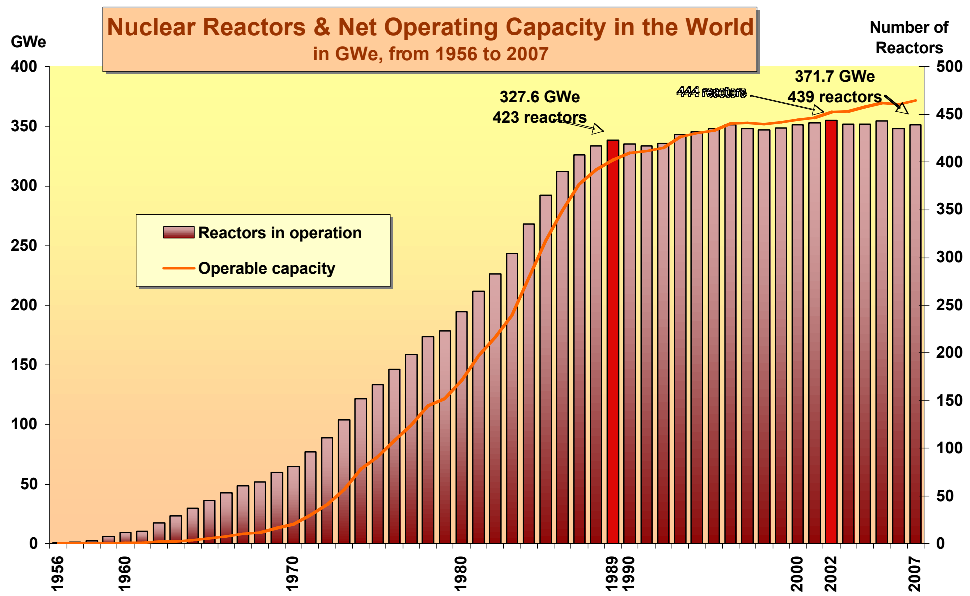
Antony Froggatt Antony Froggatt works as independent European energy consultant.
Since 1997 Antony has worked as a freelance researcher and writer on energy and nuclear policy issues in the EU and neighbouring states. He has worked extensively on EU energy issues for European Governments, the European Commission and Parliament, environmental NGOs, commercial bodies and the media. He has given evidence to inquiries and hearings in the Parliaments of, Austria, Germany and the EU. He is a part time senior research fellow at the Royal Institute of International Affairs – Chatham House in London.
He works intensively with environmental groups across Europe, particularly on energy markets and policy and helped to establish a network on energy efficiency. He is a regular speaker at conferences, universities and training programmes across the region.
Prior to working freelance Antony worked for nine years as a nuclear campaigner and co-ordinator for Greenpeace International.

Extended Summary

Fifteen years ago, the Worldwatch Institute in Washington, WISE-Paris and Greenpeace International published the *World Nuclear Industry Status Report 1992*, this was then subsequently updated in 2004 by two of the original authors. The present publication provides a revision of the 2004 report.

At the end of 2007, there are 339 units operating in the world – that is one less than at the moment of the release of the 2004 version of the World Nuclear Industry Status Report and five units less than at the historical peak in 2002 – which total about 372 GW[1] of electricity generating capacity.

Graph 1



© Mycle Schneider Consulting *Source: IAEA, PRIS, 2007*[2]*, MSC*

The installed capacity has increased faster than the number of operating reactors because units that are being shut down are usually smaller than the new ones coming on-line and because of uprating of capacity in many existing plants. In the USA the Nuclear Regulatory Commission (NRC) has approved 110 uprates since 1977. As a result an additional 4.7 GW were added to the nuclear capacity in the USA alone.[3] A similar trend of uprates and extending the lives of existing reactors can be seen in Europe. In the absence of significant new build, the average age of operating nuclear power plants in the world has been increasing steadily and is now 23 years.

A total of 117 reactors have been permanently shut down, with an average age of about 22 years. Since 2004 ten reactors have been shut down - eight in 2006 - and nine have been started up.

The capacity of the global fleet increased annually between the years 2000 and 2004 by about 3 GW, much of it through uprating and dropped to 2 GW per year between 2004 and 2007, compared to the global net increase in all electricity generating capacity of about 135 GW *per year*[4]. Wind power alone recorded an average annual increase of 13.3 GW between 2004 and 2006, more than 6.5 times the nuclear additions. This leaves nuclear power with a global share of roughly 1.5% of the annual increase.

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[1] 1 GW = 1,000 MW = about 1 large nuclear power reactor

[2] International Atomic Energy Agency (IAEA), Power Reactor Information System (PRIS), see http://www.iaea.org/programmes/a2/index.html

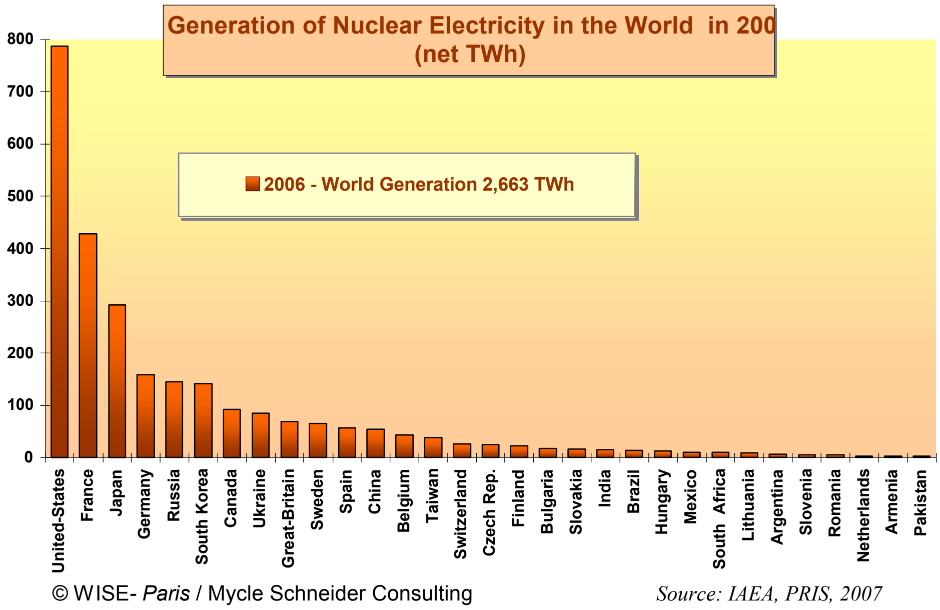
[3] http://www.world-nuclear.org/info/Copy%20of%20inf17.html

[4] This is the average annual net addition between 2003 and 2010 as estimated by the OECD's International Energy Agency in its International Energy Outlook 2006.

The slightly increased output from nuclear energy will not be sufficient, at least over the short and medium term, to maintain its current 16% share in the world commercial power production, or 6% in the commercial primary energy – which is less than the contribution of hydropower alone – or about 2% to 3% final energy consumption.[5]

Twenty-one of the 31 countries operating nuclear power plants decreased their share of nuclear power within the electricity mix when compared with 2003. The USA, France, Japan, Germany, Russia, South-Korea produce almost three quarters of the nuclear electricity in the world. Half of the world's nuclear countries are located in Western and Central Europe account for over one third of the world's nuclear production. In 1989 a total of 177 nuclear reactors had been operated in what are now the 27 EU Member States. That number shrank to 146 units as of the end of 2007. The decline of the industry has started a long time ago.

Graph 2



The international nuclear industry continues to forecast a positive future but it is not alone to proclaim its "renaissance". Over the last three years, several international assessments of the possible future of nuclear power in the world have been adjusted to more optimistic prospects for the horizon of 2030.[6][7][8][9][10] These scenarios "forecast" an installed nuclear capacity by 2030 of anything between 415 GW and 833 GW, respectively an increase of 13% to 125% over the current installed 372 GW. None of the scenarios provide appropriate analysis of the necessary and very substantial increases in nuclear related education, workforce development, manufacturing capacity and public opinion shifts.

For the immediate future new build remains essentially restricted to Asia. Of the 34 units listed by the International Atomic Energy Agency (IAEA) as under construction in twelve countries (as of the end of 2007) – eight more than by the end of 2004, but about 20 less than in the late 1990s – all but five are located

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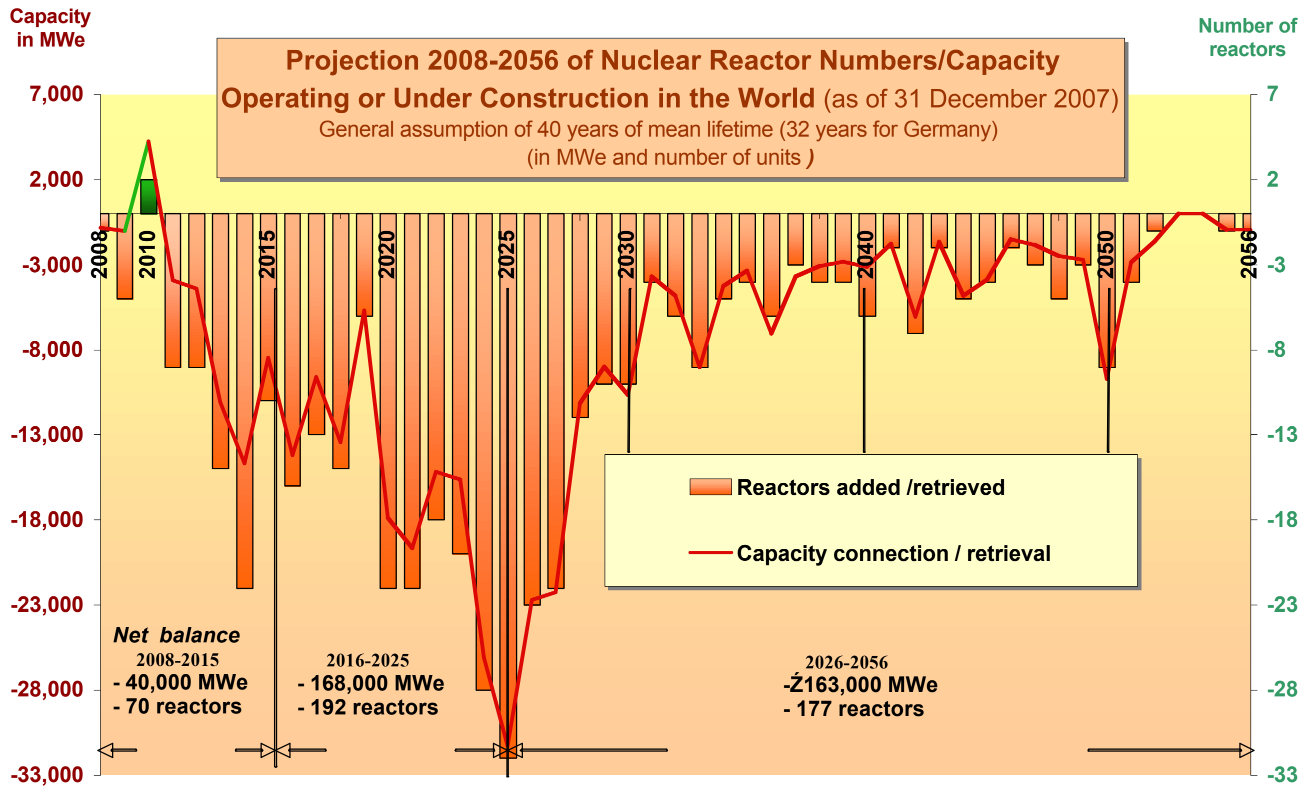
[5] Final energy is the amount of energy available to the consumer, which is the primary energy input minus the transformation and transport/distribution losses. In the case of electricity, about three quarters of the primary energy is lost on the way to the consumer.
[6] OECD-IEA, "World Energy Outlook 2007", 7 November 2007
[7] InterAcademy Council, "Lighting the Way", October 2007
[8] US Department of Energy, Energy Information Administration, "International Energy Outlook 2006", June 2006, see www.eia.doe.gov/oiaf/ieo/index.html
[9] IAEA, Press Release, 23 October 2007, http://www.iaea.org/NewsCenter/PressReleases/2007/prn200719.html
[10] UNFCCC, "Analysis of existing and planned investment and financial flows relevant to the development of effective and appropriate international response to climate change", 2007 http://unfccc.int/files/cooperation_and_support/financial_mechanism/application/pdf/background_paper.pdf

in Asia or Eastern Europe. Twelve of these units have been formally under construction for 20 years or more. The longest construction time so far has been achieved by the U.S. Watts Bar-2 reactor that just resumed construction but had originally started in 1972.

Graph 3



© Mycle Schneider Consulting *Source: IAEA, PRIS, 2007, MSC*

In order to evaluate the status of the world nuclear industry, it is helpful to estimate the number of units that would have to be replaced over the coming decades just to maintain the current number of operating plants. We have considered an average lifetime of 40 years per reactor, with the exception of the remaining 17 German nuclear reactors that, according to German legislation, will be shut down after an average operational lifetime of about 32 years.

Graph 3 illustrates the results. The scenario includes 24 reactors with an official start-up date of the 34 units listed as under construction by the IAEA as of December 2007, all but one of which would be in operation by 2015. In total, 93 units will reach the age of 40 between January 2008 and 2015 or are scheduled to be shut down for other reasons. In other words, in addition to the 23 units under construction with published start-up dates until 2015, in total 70 units or about 40 GW would have to come online by 2015 in order to maintain the current level of equipment. Even taking into account the 10 units officially under construction but without scheduled start-up date within the timeframe, 60 reactors would still have to be planned, built and started up over the next eight years to maintain the current number of units operating. This seems virtually impossible given the long lead times for nuclear power projects. Furthermore, in the following decade - up to 2025 - a total of 192 new units or more than 168 GW would be needed just to maintain the status quo. According to the same logic, between 2007 and 2030 a total of 339 reactors would have to be replaced in order to maintain the same number of plants operating than today.

Developments in Asia and particularly in China won't fundamentally change the global picture. Officially, China has "fast-tracked development of nuclear power in recent years with a target to take its nuclear power capacity from about 9,000 MW [9 GW] in 2007 to 40,000 MW [40 GW] by 2020."[11] Even in the case of significant advances in building times, in order to be operational by 2020, construction of all of the units would need to have started at the latest in 2015. Building frequency would have to more than triple over current practice in order to meet the ambitious goal. A prospect that seems highly unlikely.[12] But even such an extraordinary undertaking in terms of capital investment, technical and organizational challenge would replace only 10% of the number of units that reach age forty around the world within the timeframe considered.

In 2005 the U.S. passed legislation in order to stimulate investment in new nuclear power plants. Measures include a tax credit on electricity generation, a loan guarantee of up to 80% for the first 6 GW, additional support in case of significant construction delays for up to six reactors and the extension of limited liability until 2025. The licensing procedure has been simplified to avoid the lengthy processes of the past. Critics view the new licensing conditions not only as heavy subsidy to the industry but as serious impediment to the democratic decision making process. Legal procedures against construction licensing requests are expected in the U.S. and in the UK that could lead to lengthy delays.

Many analysts consider that the historic key problems with nuclear power have not been overcome and will continue to constitute a severe disadvantage in global market competition. New difficulties have arisen.

Scepticism of the international financial institutions and analysts

The credit rating company Standard and Poor's stresses that "no utility will commit to a project as large and risky as a new nuclear plant without assurance of cost recovery". In addition, "with increasing raw material costs, a depleted nuclear-specialist workforce, and strong demand for capital projects worldwide, construction costs are increasing rapidly".[13] The capital market service company Moody's "believes that many of the current expectations regarding new nuclear generation are overly ambitious."[14]

The international financing market's reluctance towards nuclear energy is not new. With the exception of a 1959 loan to Italy, the World Bank, for example, has never financed a nuclear power plant and there are no signs that it would have changed its financial risk analysis. Even the Asian Development Bank does not finance nuclear projects and has defined clear policy on the issue in 1994, which it has confirmed in 2000 due to a range of specific concerns, including "issues related to transfer of nuclear technology, procurement limitations, proliferation risks, fuel availability and procurement constraints, and environmental and safety aspects. The Bank will maintain its policy of non-involvement in the financing of nuclear power generation"[15].

Lack of students, workforce and manufacturing capacity

Investment and construction ratios of the 1980s cannot simply be repeated thirty years later. The nuclear industry and utilities face challenges in a radically changed industrial environment. Today the sector has to deal with waste management and decommissioning expenses that far outweigh estimates of the past, it has to compete with a largely modernized gas and coal sector and with new competitors in the renewable energy sector.[16] In particular, it has to face the problems of rapid loss of competence and lack of manufacturing infrastructure.

In the U.S. 40% of the current nuclear power plant workers are eligible for retirement within the next five years.[17][18] In France, the situation is no better. About 40% of the national utility EDF's current staff in reactor operation and maintenance will retire by 2015.[19]

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[11] http://www.chinadaily.com.cn/china/2007-10/16/content_6177053.htm

[12] A certain number of units currently in the planning stage are of designs that have never been built elsewhere.

[13] Swami Venkataraman, "Which Power Generation Technologies Will Take The Lead In Response To Carbon Controls?", Standard & Poors, 11 May 2007

[14] Moody's Corporate Finance, op.cit.

[15] Bank Policy Initiatives for the Energy Sector, February 1994, Asian Development Bank, page 10, paragraph 25.

[16] see Amory B. Lovins' brilliant analysis "Mighty Mice", Nuclear Engineering International, December 2005

[17] Teresa Hansen « Nuclear renaissance faces formidable challenges », Power Engineering, see http://pepei.pennnet.com/Articles/Article_Display.cfm?ARTICLE_ID=297569&p=6&dcmp=NPNews

[18] AREVA's US recruiting official puts the figure at 27% within the next three years (see http://marketplace.publicradio.org/display/web/2007/04/26/a_missing_generation_of_nuclear_energy_workers/)

In 1980, there were about 65 university nuclear engineering programs operating in the U.S.. Today, it's only around 29. The entire utility industry is hunting students at the university doors before they even graduate. Westinghouse is looking for new staff in about 25 colleges and universities throughout the world. In the UK the situation is similar and as of 2002, there was not a single undergraduate course in nuclear engineering in the UK. In Germany the situation is dramatic. The number of academic institutions teaching nuclear related matters is expected to decline from 22 in 2000 to 10 in 2005 and only five in 2010.[20] While 46 students obtained their diploma in 1993, between the end of 1997 and the end of 2002 *in total* only two students successfully finished their nuclear studies.[21]

Equally problematic is the manufacturing bottleneck. Major equipment (reactor pressure vessels, steam generators, and moisture separator reheaters) for the near-term deployment in the U.S. of Generation III[22] units would not be manufactured by U.S. facilities. "Reactor pressure vessel (RPV) fabrication could be delayed by the limited availability of the nuclear-grade large ring forgings that are currently only available from one Japanese supplier (Japan Steel Works, Limited - JSW). Additional lead time may need to be included in the reactor pressure vessel procurement schedule depending on ability of this one supplier to supply the required reactor pressure vessel large ring forgings in a timely manner. This potential shortfall is a significant construction schedule risk and could be a project financing risk."[23] In fact, only JSW can forge components needed for the EPR and other Generation III reactor pressure vessels The U.S. Nuclear Regulatory Commission has warned that it will take more time to inspect foreign made components than to provide quality control at home.[24]

Rhetoric rather than reality

Much of the optimism displayed by the nuclear lobby is limited to rhetoric. The overall nuclear industry strategy is quite clear. In the absence of a short or medium term revival of the nuclear industry, hopes remain with an entirely new generation of nuclear power plants, so-called Generation IV reactors. These maybe much smaller in size (100 MW to 200 MW) and capital investment requirement, represent a more flexible solution due to much shorter building times and a lower potential risk due to smaller radioactive inventories and passive safety features. In the meantime, nuclear utilities try to extend plant lifetime as much as possible and do their best to keep up the myth of a nuclear future.

In June 2005, the trade journal Nuclear Engineering International published the analysis of the 2004 Edition of the World Nuclear Industry Status Report under *their* headline. "On the way out - In sharp contrast to multiple reporting of a potential 'nuclear revival', the atomic age is in the dusk rather than in the dawn".

At the end of 2007, we have nothing to add.

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19 GIGA, "L'industrie nucléaire française : perspectives, métiers / Le besoin d'EDF en 2008", October 2007, http://www.giga-asso.com/fr/public/lindustrienucleairefranc/emploisperspectives1.html?PHPSESSID=2f7kmsonapea7ihktecmvdks45

20 P. Fritz and B. Kuczera, "Kompetenzverbund Kerntechnik – Eine Zwischenbilanz über die Jahre 2000 bis 2004", Atomwirtschaft, June 2004

21 Lothar Hahn, presentation at the IAEA sponsored "International Conference on Nuclear Knowledge Management: Strategies, Information Management and Human Resource Development", 7-10 September 2004

22 The currently operating generation of nuclear plants is considered Generation II. The EPR under construction in Finland is considered a Generation III reactor. Other designs under consideration in the US include the AP1000 by Westinghouse, the Advanced Boiling Water Reactor (ABWR) and the Economic Simplified Boiling Water Reactor (ESBWR) by General Electric.

23 MPR, "DOE NP2010 Nuclear Power Plant Construction Infrastructure Assessment", 21 October 2005

24 Financial Times, 24 October 2007

***Table 1: Status of Nuclear Power in the** World (as of 31 December 2007)*

Countries	*Nuclear Reactors*[25]				*Power*[26]	*Energy*[27]
	Operate	Average Age	Under Construction[28]	Planned[29]	Share of Electricity[30]	Share of Commercial Primary Energy[31]
Argentina	**2**	**29**	**1**	**1**	**7%(–)**	**2%(–)**
Armenia	**1**	**27**	**0**	**0**	**42%(+)**	**?%**
Belgium	**7**	**27**	**0**	**0**	**54%(–)**	**15%(–)**
Brazil	**2**	**16**	**0**	**1**	**3%(–)**	**2%(=)**
Bulgaria	**2**	**18**	**2**	**0**	**44%(+)**	**22%(+)**
Canada	**18**	**23**	**0**	**4**	**16%(+)**	**7%(–)**
China	**11**	**7**	**5**	**30**	**2%(–)**	**1% (=)**
Czech Republic	**6**	**16**	**0**	**0**	**32%(+)**	**14%(+)**
Finland	**4**	**28**	**1**	**0**	**28%(+)**	**20%(–)**
France	**59**	**23**	**1**	**0**	**78%(+)**	**39%(–)**
Germany	**17**	**25**	**0**	**0**	**32%(–)**[32]	**12%(–)**
Hungary	**4**	**22**	**0**	**0**	**38%(+)**	**12%(+)**
India	**17**	**16**	**6**	**10**	**3%(–)**	**1%(=)**
Iran	**0**	**0**	**1**	**2**	**0%(=)**	**0%(=)**
Japan	**55**	**22**	**1**	**12**	**30%(+)**	**13%(–)**
Korea RO (South)	**20**	**14**	**3**	**5**	**39%(–)**	**15%(+)**
Lithuania	**1**	**20**	**0**	**0**	**72%(–)**	**24%(–)**
Mexico	**2**	**16**	**0**	**0**	**5%(–)**	**2%(=)**
Netherlands	**1**	**34**	**0**	**0**	**4%(–)**	**1%(=)**
Pakistan	**2**	**22**	**1**	**2**	**3%(+)**	**1%(=)**
Romania	**2**	**6**	**0**	**2**	**9%(–)**	**3%(=)**
Russia	**31**	**25**	**7**	**8**	**16%(–)**	**5%(=)**
Slovakia	**5**	**19**	**0**	**2**	**57%(–)**	**23%(+)**
Slovenia	**1**	**26**	**0**	**0**	**40%(–)**	**?%**
South Africa	**2**	**23**	**0**	**1**	**4%(–)**	**2%(=)**
Spain	**8**	**24**	**0**	**0**	**20%(–)**	**9%(+)**
Sweden	**10**	**28**	**0**	**0**	**48%(–)**	**33%(=)**
Switzerland	**5**	**32**	**0**	**0**	**37%(–)**	**22%(+)**
Taiwan	**6**	**26**	**2**	**0**	**33%(–)**	**8%(–)**
Ukraine	**15**	**19**	**2**	**2**	**48%(+)**	**15%(+)**
United Kingdom	**19**	**26**	**0**	**0**	**18%(–)**	**8%(–)**
USA	**104**	**28**	**1**	**7**	**19%(–)**	**8%(=)**
EU27	**146**	**24**	**4**	**5**	**30%**	**13%(–)**
Total	**439**	**23**	**34**	**89**	**16%**	**6%(–)**

[25] according to IAEA PRIS November 2007, http://www.iaea.org/programmes/a2/index.html unless noted otherwise
[26] in 2006, according to IAEA PRIS November 2007, http://www.iaea.org/programmes/a2/index.html
[27] in 2006, according to BP Statistical Review of World Energy, June 2007
[28] as of 1 November 2007
[29] adapted from WNA 2007, http://www.world-nuclear.org/info/reactors.html
[30] +/-/= in brackets refer to change versus level in 2003 (reference for the 2004 World Nuclear Industry Status Report)
[31] +/-/= in brackets refer to change versus level in 2003 (reference for the 2004 World Nuclear Industry Status Report)
[32] German statistics (AG Energiebilanzen) give the share in the gross national power generation as only 26.4%, in decline since 1997

Appendix-1: Nuclear Reactors Listed as "Under Construction" as of 31 December 2007

Country	Units	MWe (net)	Construction Start	Planned Grid Connection
ARGENTINA	1	692	1981/07/14	?
BULGARIA	2	1906		
Belene-1		*953*	1987/01/01	?
Belene-2		*953*	1987/03/31	?
CHINA	5	3220		
Hongyanhe		*1000?*	2007/08/18	?
Lingao-3		*1000*	2005/12/15	2010/08/31
Lingao-4		*1000*	2006/06/15	?
Qinshan-II-3		*610*	2006/03/28	2010/12/28
Qinshan-II-4		*610*	2007/01/28	2011/09/28
FINLAND	1	1600	2005/08/12	2010/12/01*
FRANCE	1	1600	2007/12/03	summer 2011
INDIA	6	2910		
...Kaiga-4		*202*	2002/05/10	2007/07/31**
...Kudankulam-1		*917*	2002/03/31	2009/01/31
...Kudankulam-2		*917*	2002/07/04	2009/07/31
...PFBR		*417*	2004/10/23	?
...Rajasthan-5		*202*	2002/09/18	2007/06/30**
...Rajasthan-6		*202*	2003/01/20	2007/12/31
IRAN	1	915	1975/05/01	2007/11/01***
JAPAN	1	866	2004/11/18	2009/12/01****
PAKISTAN	1	300	2005/12/28	2011/05/31
RUSSIA	7	4585		
...Balakovo-5		*950*	1987/04/01	2010/12/31
...BN-800		*750*	1985*****	?
...Kalinin-4		*950*	1986/08/01	2010/12/31
...Kursk-5		*925*	1985/12/01	2010/12/31
...Severodvinsk-1		*30*	2007/04/15	?
...Severodvinsk-2		*30*	2007/04/15	?
...Volgodonsk		*.950*	1983/05/01	2008/12/31
SOUTH KOREA	3	2880		
…Shin-Kori-1		*960*	2006/06/16	2010/08/01
…Shin-Kori-2		*960*	2007/06/05	2011/08/01
…Shin-Wolsong-1		*960*	2007/11/20	2011/05/28
TAIWAN******	2	2600		
...Lungmen-1		*1300*	1999	2010
...Lungmen-2		*1300*	1999	2010
UKRAINE	2	1900		
...Khmelnitski-3		*950*	1986/03/01	2015/01/01
...Khmelnitski-4		*950*	1987/02/01	2016/01/01
USA	1	1165	1972/12/01	?
Total:	**34**	**27139**		

Sources: IAEA PRIS, December 2007, except otherwise noted

Notes:
* This date refers to the new planned start-up of the plant. However, the plant owner TVO has so far reported dates for the "commercial operation" of the plant, that usually takes place several months after the initial start-up. It is possible that the new delays reported in December 2007 will postpone commercial operation to the end of 2011. (TVO, Press Release, 28 décembre 2007, see http://www.tvo.fi/1016.htm
** As of the end of 2007, the unit was not reported as connected to the grid.
*** As of the end of 2007, the unit was not reported as connected to the grid.
**** This date refers to the planned start of commercial operation of the plant.
***** The IAEA Power Reactor Information System (PRIS) curiously provides a new construction start date as 2006/07/18. Until 2003, the French Atomic Energy Commission (CEA) listed the BN-800 as « under construction » with a construction start-up date « 1985 ». In subsequent editions, of the CEA's annual publication *ELECNUC, Nuclear Power Plants in the World*, the BN-800 had disappeared.
****** Data on Taiwan from http://www.world-nuclear.org/info/inf115_taiwan.html