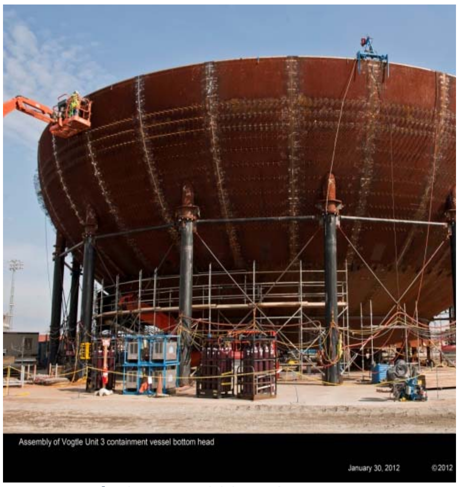
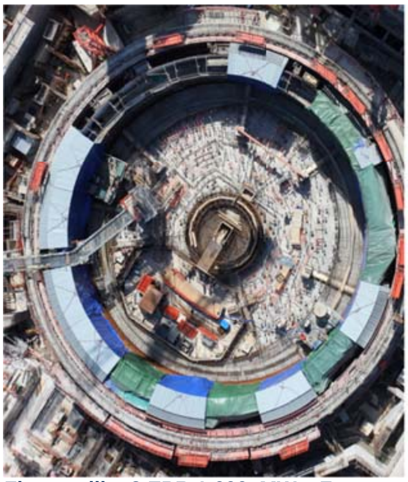
Worldwide Panorama of Nuclear Energy

Ohi 3 - 4 PWR 2,360 MW –Japan



Vogtle 3 – AP1,000 - USA



Flamanville -3 EPR 1,600 MW – France

November

Edition

2013

SURRY 1-2 PWR 1,780 MW - USA

Hanul 1-6 PWR 6,189 MW - South Korea

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Note: Comments will be welcome and can be sent to:

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This report was originally written in Portuguese.

Introduction

It is probably that the Fukushima-Daiichi accident in Japan marked the end of isolation for the nuclear energy industry in the world, which now needs, more than ever, new global leaders who can focus on lessons learned after the accident.

The proposed solutions until now will require millions of dollars in investment in all countries with nuclear technology but as a result the security will be greatly enhanced and will generate more jobs also. New projects will be more accurate due to the new restrictions to withstand extreme events that have been added to the basis of design

According to the International Energy Agency (IEA), in 'World Energy Outlook 2012' Nuclear energy output could rise by 58 percent by 2035, but nuclear's share of world energy generation will fall from 13 percent to 12 percent because the ambitions for nuclear have been "scaled back" as countries have reviewed policies following the accident at Fukushima-Daiichi. The capacity is still projected to rise, led by China, South Korea, India and Russia.

The society's support to nuclear technology is essential for its success and for this the adequate communication is fundamental. The information must be accurate and timely in order to create the foundation of public trust in general and in particularly those who perchance may be affected by the operations of nuclear companies, especially those who may be affected by the operations of nuclear companies.

Currently the Internet is available 24 hours a day in virtually every country. Companies need to rethink how they communicate the event of an accident, preparing to listen to concerns and answer all questions with openness and transparency. They need to work hard and train their communicators more because the questions are always new.

The decommissioning of nuclear power plants at the end of life in the coming years will require huge investments and availability of skilled human resources not available in the market today. The same can be said for implementing a permanent solution to the radioactive waste in general and especially those of high activity.

Currently around 150,000 people work with nuclear energy and applications and from these approximately 38% are preparing for retirement within 5 years. The replacement of this highly skilled workforce requires own policies in each country, with the creation of courses in universities that will attract students only if there will be prospects for future jobs. There are still areas of research that will require large contingent.

To answer a decarbonized economy, as proposed by the UN to deal with climate change, nuclear energy stands as an available and proven technology to contribute to low operating costs and for long time to the energy matrices mix needed today. Barriers created by governments due political reasons need to be reconsidered for the good of its own inhabitants.

WORLD PANORAMA OF NUCLEAR ENERGY

I – Highlights of the November 2013 Edition

In 2013, up to November

- 435 nuclear power reactors in operation with an installed total net capacity of 370,536 GW(e)
- 71 nuclear power reactors under construction (net capacity of 66,831 MW(e)

Permanent shutdowns

- Crystal River 3 (860 MW(e), PWR, USA) on 5 /02/2013
- Kewaunee (566 MW(e), PWR, USA on 7/05/2013
- San Onofre 2 (1070 MW(e), PWR, USA) on 7 /06/2013
- San Onofre 2 (1070 MW(e), PWR, USA) on 7 /06/2013

Connections to the grid

- Hongyanhe-1 (1000 MW(e), PWR, CHINA) on 18 /02/2013

Construction starts

- Virgil C. Summer 2 (1117 MW(e), PWR, USA) on 9 /03/2013
- Virgil C. Summer 3 (1117 MW(e), PWR, USA) on 4 /11/2013
- Vogtle-3(1117 MW(e), PWR, USA) on 12 /03/2013
- Barakah 2(1345 MW(e), PWR, UAE) on 28 /05/2013
- Shin-Hanul-2(1340 MW(e), PWR, KOREA REP.) on 19 /06/2013
- Yangjiang 5 (1000 MW(e), PWR, China) on 19 /06/2013
- Tianwan 4 (1050 MW(e), PWR, China) on 27 /09/2013

In 2012:

Construction starts

- Baltiisk-1 (1082 MW(e), PWR, Russia) on 22/02/2012
- Shin-Ulchin-1 (1340 MW(e), PWR, KOREA REP.) on 10/07/2012
- Barakah 1 (1340 MW(e), PWR, UAE) on 18/07/2012

Connections to the grid

- Shin –Wolsong 1 (960 MW(e), PWR, South Korea) on 27/01/2012
- Shin –Kori -2 (960 MW(e), PWR, South Korea) on 28/01/2012

Restarts after long-term shutdown

- Bruce-1 (772 MW(e), PHWR, CANADA) on 19 /09/2012
- Bruce-2 (772 MW(e), PHWR, CANADA) on 16 /10/2012

Definitive closure

- Oldbury A1 (217 MW(e), GCR, Great Britain on 29/02/2012
- Wylfa (490 MW(e), GCR, Great Britain on 25/04/2012

In 2011:

- 435 nuclear power reactors in operation with an installed total net capacity of 368,192MW(e)
- 63 nuclear power reactors under construction

Connections to the grid in 2011:

- Kaiga 4 (202 MW(and), PHWR, India) – on 01/19/2011
- Chasnupp 2 (300 MW(and), PWR, Pakistan) – on 03/14/2011

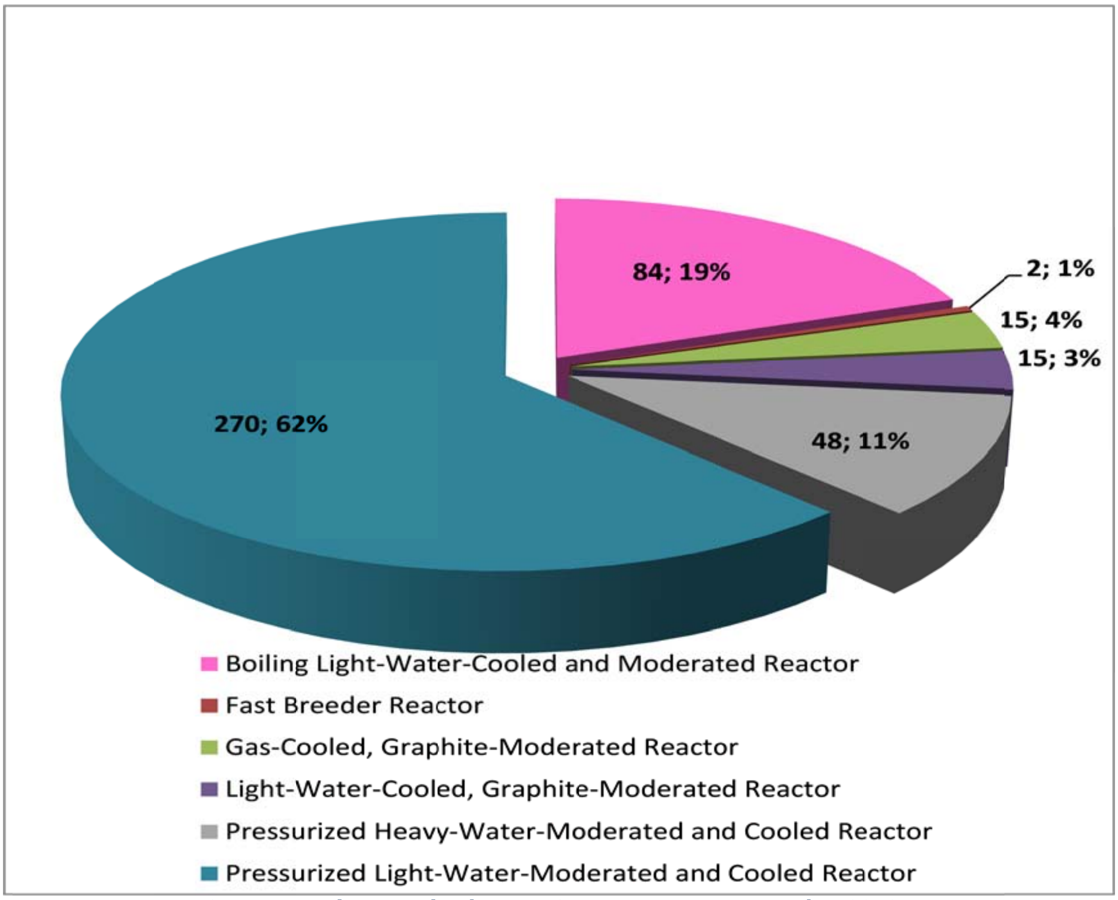
- Lingao 4 (1000 MW(and), PWR, China) – on 05/03/2011
- CEFR - (20 MW(and), FBR, China) – Experimental fast breeder reactor on 07/21/2011
- Bushehr 1 (915 MW(and), PWR-VVER, Iran) – on 09/03/2011
- Kalinin4 (950 MW(and), PWR-VVER, Russia) – on 11/14/2011
- Qinshan 2-4 (610 MW(e), PWR, China) – on 11/25/2011

Construction start date in 2011:

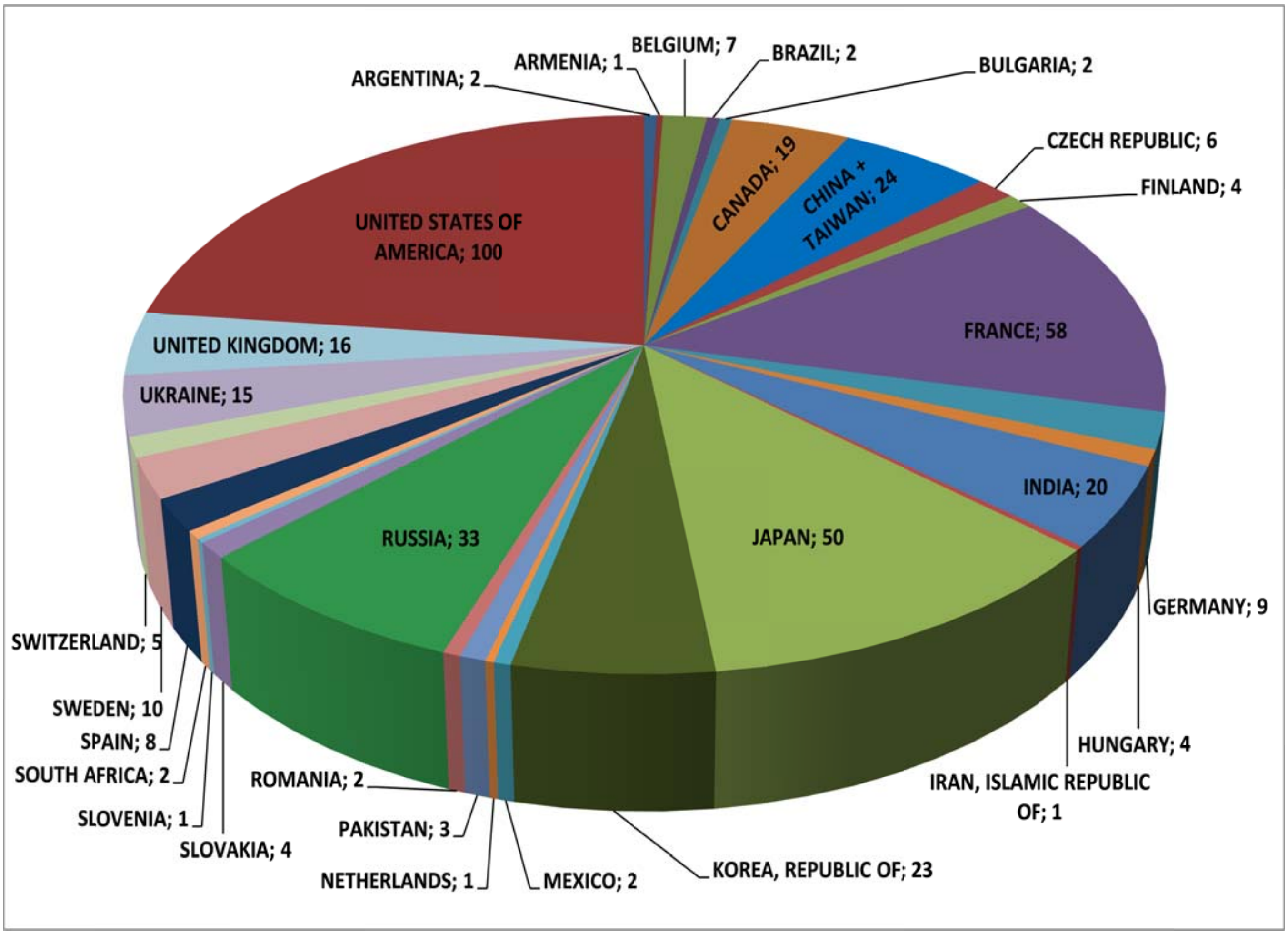
- Chasnupp 3 (315 MW(and), PWR, Pakistan) – on 05/28/11
- Rajasthan 7 (630 MW(and), PHWR, India) – on 07/18/11

Definitive closure:

- Fukushima-Daiichi 1,2,3,4 (439/760/760/760 MW(and), BWR, Japan) - were officially declared closed on 05/20/11
- Oldbury A2 (217 MW(and), GCR-Magnox, England) on June 30 – End of useful lifetime
- Biblis A and B (1167/1240 MW(and), PWR, Germany) were officially declared closed on 08/06/11
- Brunsbuettel (771 MW(and), BWR, Germany) were officially declared closed on 08/06/11
- Isar 1 (878 MW(and), BWR, Germany) were officially declared closed on 08/06/11
- Kruemmel (1346 MW(and), BWR, Germany) were officially declared closed on 08/06/11
- Neckarwestheim 1(785 MW(and), PWR,Germany) were officially declared closed on 08/06/2011
- Philippsburg 1 (890 MW(and), BWR, Germany) were officially declared closed on 08/06/11
- Unterweser (1345 MW(and), PWR, Germany) were officially declared closed on 08/06/11.

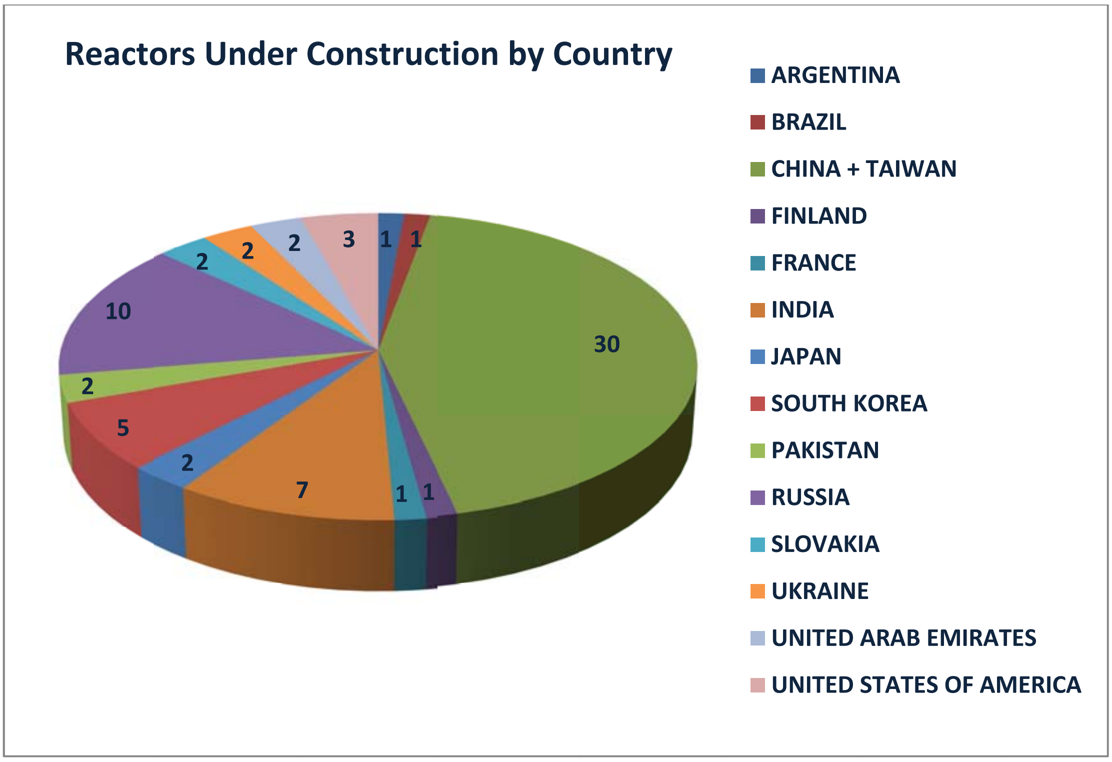


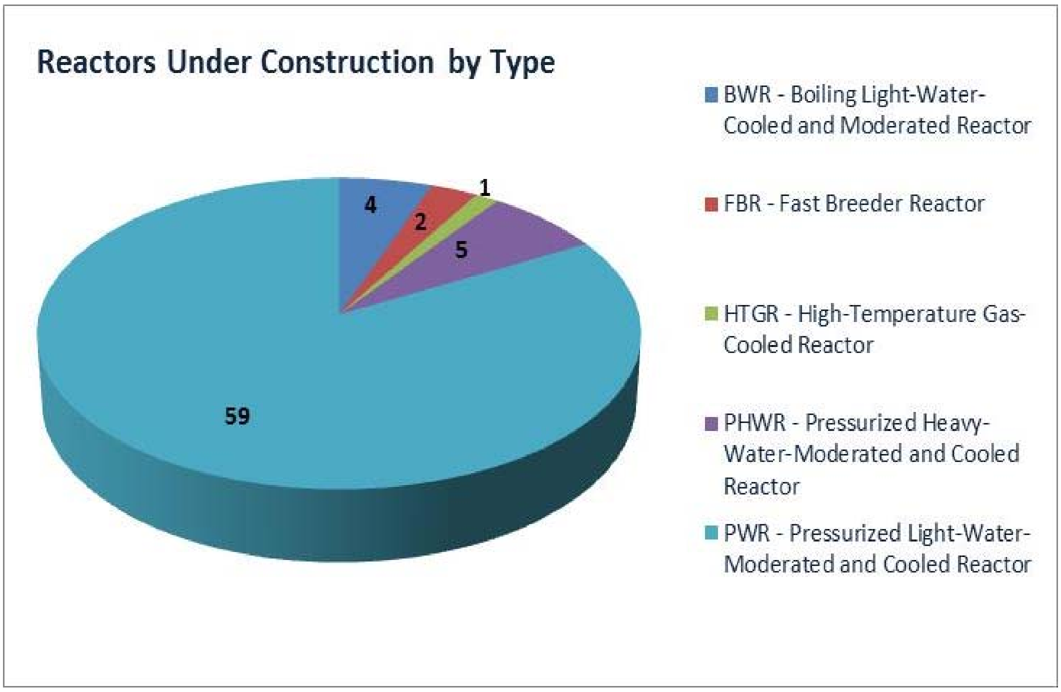
435 Reactors in operation by type Country - IAEA – November 2013



435 Reactors in operation by Country
IAEA – November 2013

- 15 Countries, representing half of world population build 69 new reactors with total net capacity of 66,831 MW(e).
- 65 Countries holding no nuclear technology have expressed to the IAEA their interest in this matter, as they plan to build reactors and/or to develop an industrial nuclear capability.





71 Reactors under construction by type

Reactors in operation or operationals

Country	Number of Reactors	Total Net Electrical Capacity [MW]
ARGENTINA	2	935
ARMENIA	1	375
BELGIUM	7	5927
BRAZIL	2	1990
BULGARIA	2	1906
CANADA	19	13500
CHINA+TAIWAN	24	18888
CZECH REPUBLIC	6	3804
FINLAND	4	2752
FRANCE	58	63130
GERMANY	9	12068
HUNGARY	4	1889
INDIA	21	5308
IRAN, ISLAMIC REPUBLIC	1	915
JAPAN	50	44215
KOREA, REPUBLIC OF	23	20739
MEXICO	2	1640
NETHERLANDS	1	482
PAKISTAN	3	725
ROMANIA	2	1300
RUSSIA	33	23643
SLOVAKIA	4	1816
SLOVENIA	1	688
SOUTH AFRICA	2	1860
SPAIN	8	7567
SWEDEN	10	9474
SWITZERLAND	5	3308
UKRAINE	15	13107
UNITED KINGDOM	16	9231
UNITED STATES OF AMEI	100	98560
Total	**435**	**371712**

Summary of Analyses and Procedures adopted by most countries after the accident Fukushima

After the accident at Fukushima in Japan in March 2011, the entire nuclear industry mobilized for the evaluation of the event and steps to be taken to ensure that these facts would not repeate in other nuclear power plants. The lessons from the event generated a series of actions as a result of the evaluations that each country has made. The issues, problems and solutions are not common to all reactors or to all countries.

For some cases it will be necessary change the regulatory structure of the countries' regulators with the intention of making agencies more independent, but most of countries did analyzes focused on ensuring the reactors ability to withstand extreme events (earthquakes and other seismic events, tsunami, floods, windstorms and hurricanes) and the behavior of security systems and safe shutdown of the plants. They also evaluated the processes and planning for external response to nuclear emergencies and SAMG's (Severe Accidents Management Guidelines)

A summary of key actions by country is following. Evaluations undertaken by countries and their regulators generate programs and procedures to solve any weaknesses and have been or are being developed:

Planned post-Fukushima actions, by country and broad issue (as of 1 December 2011)

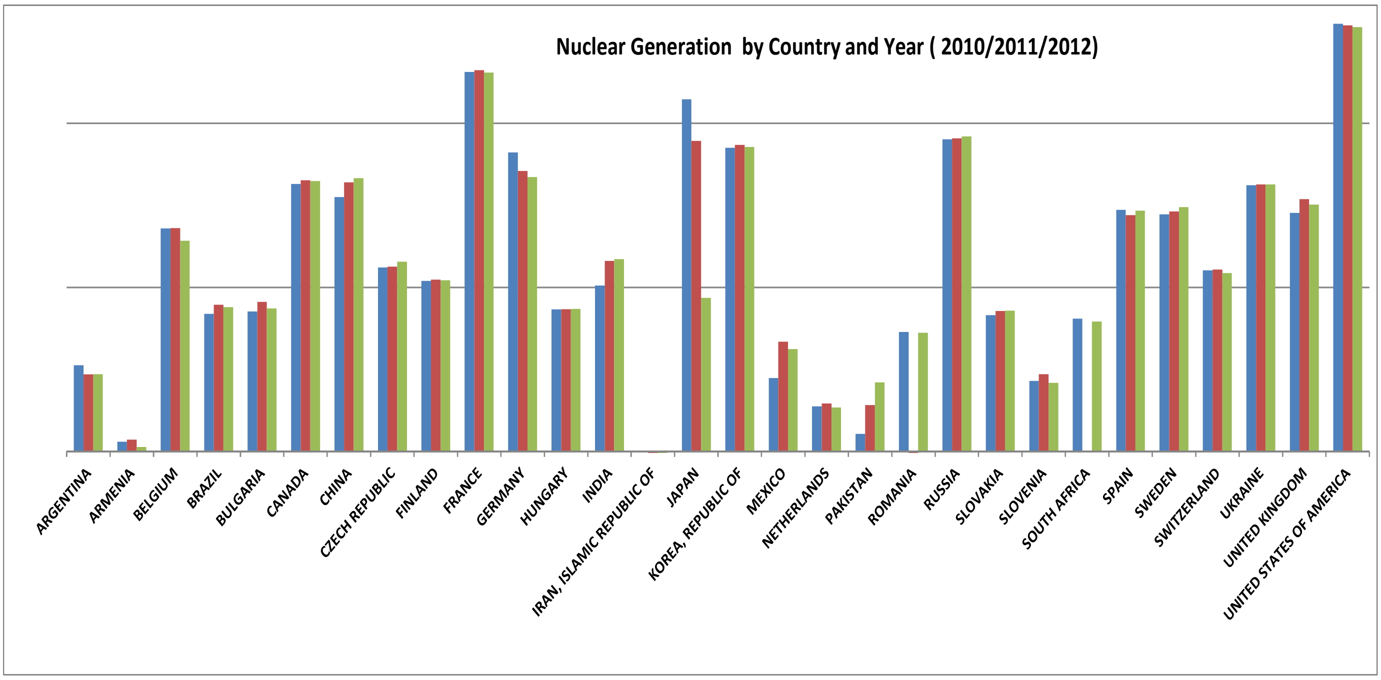
Country	Regulatory structure	Seismic resistance	Tsunami/flood defences	Install emergency diesels	Emergency cooling pumps	Spent fuel pool cooling	SFP instrumentation	Hydrogen recombiners	Containment vents	SAMGs	Multi-unit analysis	Emergency response
Belgium		X		X	X	X	X			X		
Brazil		X	X	X	X					X		X
Bulgaria		X	X	X						X		
Canada		X					X	X	X	X	X	X
Czech Republic		X		X				X				X
Finland		X	X	X	X	X	X	X				
France				X	X					X		X
Germany				X	X					X	X	
Hungary		X				X		X	X	X		
India	X	X	X	X	X	X		X				
Japan	X		X	X	X			X	x	X		X
Korea, South	X	X	X	X	X	X		X	X	X	X	X
Lithuania			X	X	X							
Romania		X		X	X			X	X	X		X
Russia		X	X	X	X	X				X	X	
Slovakia				X	X	X		X	X	X		X
Slovenia			X	X	X			X		X		
South Africa				X	X			X				
Spain		X		X	X			X	X	X		X
Sweden		X	X	X	X	X		X		X	X	
Switzerland		X	X	X	X	X	X					X
Taiwan	X		X	X	X	X	X	X			X	
Ukraine		X	X	X	X			X	X			X
UK		X	X			X		X	X	X		X
USA		X	X	X	X	X	X		X	X	X	

The main actions are concentrated in areas where there are potential for improvements:

- Country Regulatory Structure;
- Seismic resistance evaluation of each reactor;

- Checking of Tsunami/flood defenses;
- Install new emergency Diesels;
- Checking Emergency cooling pumps;
- Evaluation of Spent Fuel Pool Cooling;
- Checking of Instrumentation's Spent Fuel Pool;
- Hydrogen's Recombiners
- Containment Vent
- SAMG's (Severe Accidents Management Guidelines)
- Multi-unit Analysis;
- Emergency Response

The comparison of nuclear power generation in the years 2010 and 2011 shows that some countries have reduced their nuclear generation, but most of then has increase the energy generated by this source from one year to the next. Only Japan, which took off much of its fleet for tests after the earthquake and tsunami of March 2011 and Germany have turned off some of its reactors spontaneously, had a reduction in its nuclear power generation.



II - World Nuclear electricity generation

With the global growth in energy consumption, a lot of efforts have been made toward increasing electricity generating capacity, and nuclear energy stands as one of the leading technologies for the future of the nuclear power industry. It provides one of the best heat generation rates among other thermal electricity generation sources, emitting no greenhouse gases. Also, being deployable in a small area with a powerful fuel at a highly competitive price, nuclear energy allows large-scale electricity production by suitably functioning as a component of the power grid's baseload fleet.

So that the functions of modern society can be appropriately performed (setting industry in motion, commerce, providing communication, health, public services, etc...) energy is an essential staple to rely on, especially electric energy supplied in a reliable manner, at a suitable price. Energy supply and security is currently an essential requirement for any country, and a key driver for many of the strategic decisions made by governments.
Total electricity generation data has been furnished by the companies involved, always on an annual basis. In 2011, the United States was the country that most generated electricity from nuclear power, accounting for around 32% of the world's total production of such form of energy.

Other leading electricity producing countries were: France (17%), Japan (6,3%), Germany 4%), Russia (6,5%), South Korea (6%), Canada (3%), Ukraine (3,4%) and China + Taiwan (4%). Brazil was responsible for 0,6% of the world's electricity generation from nuclear power.

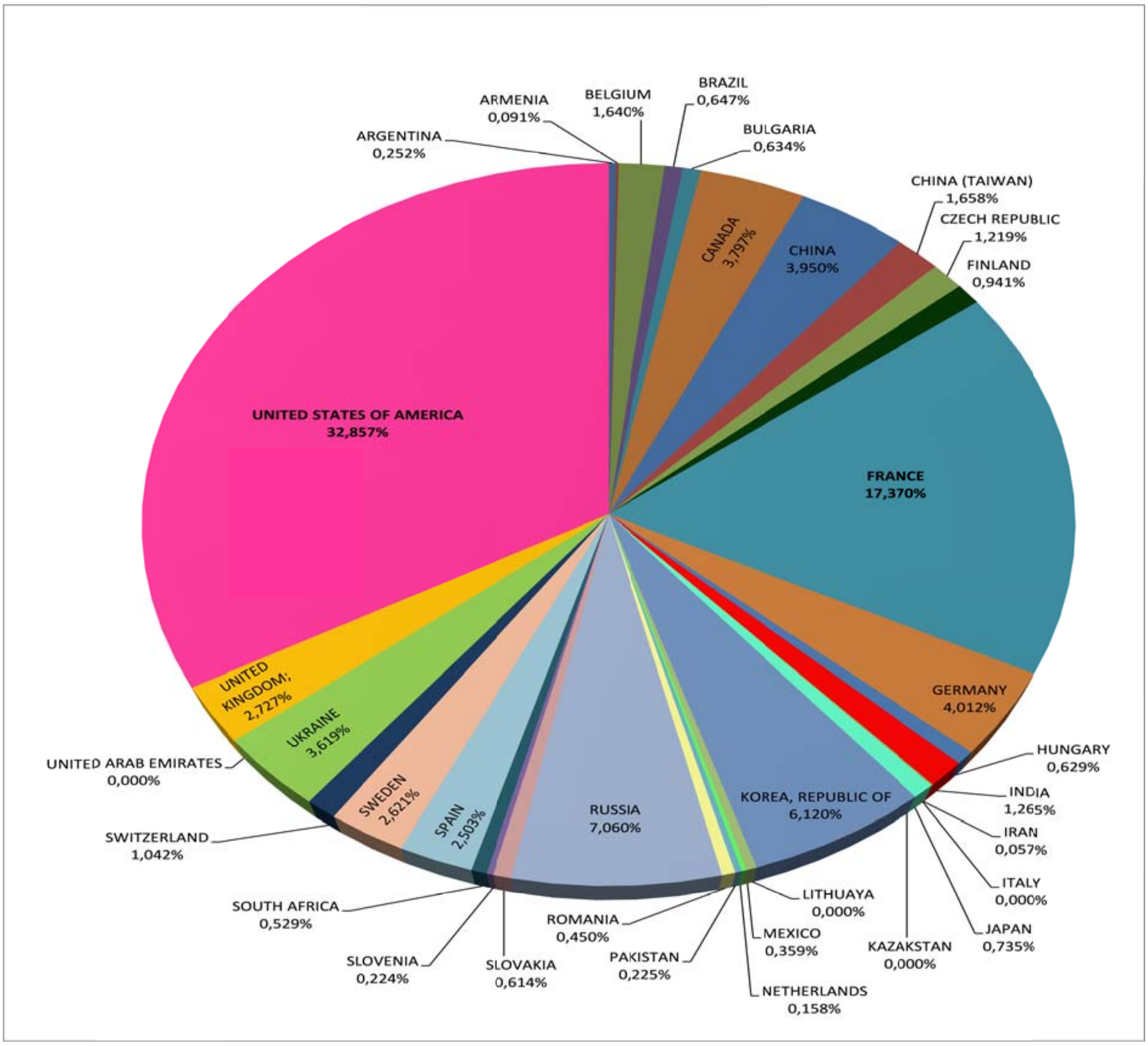
France decreased its production of nuclear energy in 2012 that reached 407,438 GWh primarily due to outages longer stops in the period. In Japan, production was 17,230GWh, with huge drop compared to 2011 when it reached 156,182 GWh as a result of the accident at Fukushima Daiichi. Only two reactors are in operation. Germany produced 94,098 GWh gross with small reduction compared to 2011 when it reached 96,951.12 GWh net.

According to the International Energy Agency (IEA), in 'World Energy Outlook 2012' Nuclear energy output could rise by 58 percent by 2035, but nuclear's share of world energy generation will fall from 13 percent to 12 percent because the ambitions for nuclear have been "scaled back" as countries have reviewed policies following the accident at Fukushima-Daiichi.
The capacity is still projected to rise, led by China, South Korea, India and Russia.

The IAEA adopted a resolution to encourage and support the development of nuclear applications in developing countries in order to reduce the existing wide distance between the average annual consumption by developed countries (about 8,600 KWh per inhabitant - OECD) and, for example, that of the African continent which is 170 lower, inasmuch improving such indicator is the driver of progress and well-being of the needier population.

At present, 65 countries holding no nuclear technology have expressed to the IAEA their interest in this matter, as they plan to build reactors and/or to develop an industrial nuclear capability. Expanding world powers want to multiply the number of power plants in their territory.

Even after the accident at the Fukushima nuclear power station in Japan, many governments consider the international expansion of nuclear energy an option to climate change and an alternative to oscillations in the prices of energy products, and a protection against the uncertainties of fossil fuel supply. The worldwide expansion of nuclear energy requires that governments act responsibly and enforce strict safety criteria on the operation of nuclear facilities.



Participation by country in the world nuclear power generation – 2012

The major barriers to the nuclear option have to do with the safety of nuclear plants, disposal of radioactive wastes and proliferation of nuclear weapons, in addition to the costs of construction and maintenance. Also to be considered is the difficulty involved in supplying large-sized nuclear components.

Additionally the IEA projects the necessity for governments to mitigate the financial risks of nuclear constructions and projects through specific policies, such as by including the carbon price in generation costs, so that the nuclear source's 375 GWe required for starting operations between 2020 and 2030, both in replacing old plants and in new electricity generation projects can obtain the adequate investment.

III - Distribution of Reactors

Among the largest electricity generating fleets, the following countries stand out: the United States with 104 units, France with 59 reactors and Japan, 53. In 2010, construction was started on fourteen new plants, and five new ones were connected to their grids. But mention should be made of the definitive closure of the Phenix (130 MW(and), FBR, France) on 02/01/10. According to the World Nuclear Association - WNA up to November 2011 the experience gained all over the world by nuclear power reactors (summation of all reactors' years of operation), was more than 14,660 years, with the power generation of around 61,200 TWh.

The table below shows the world's largest suppliers of nuclear technology:

Suppliers	Reactor Type
GE	ABWR / ESBWR
Westinghouse	AP1000
Areva	EPR
AECL	ACR 700
Mitsubish	USA PWR
Toshiba	ABWR
General Atomics	GTMHR
Eskon	PBMR

The shortage of large forgings is a problem to be tackled by the world's major constructors of new nuclear reactors. There exist not many manufacturers of reactor pressure vessels, steam generators or large turbines. For example, Japan Steel Works, which holds 80% of the large forgings market, acknowledges that it has a capacity for only 4 vessels a year.

The Nuclear Engineering Institute - NEI warns that the relevant arrangements should not be delayed, on pain of impacting the construction schedule of new plants. Other large manufacturing companies are China First Heavy Industries and China Erzhong, Russia's OMZ Izhora, Korea's Doosan, France's Le Creusot and India's JSW. All of them are expanding their capacities. The most recent developments are in Germany, which set up a new fabrication plant at Völklingen and the French company Alstom, which opened up a new fabrication plant in the United States to meet the needs for large turbines and turbine generators and other equipment items for gas- and nuclear-fueled power plants in the U.S. market. Also, new fabrication plants are planned in England, India and China.

Consortia "Areva/Mitsubishi, Westinghouse-Toshiba, and GE-Hitachi are vendors holding larger production scale and technology to cause real impact on the nuclear industry. Mention should also be made of Korean and Russian companies. Because of the small number of competitors, the market is likely to go through a scaling up of prices in general.

Following the nuclear accident in Fukushima Dai-íche in Japan some consequences could be observed as: It was in Japan itself that supply problems are most critical. Japan Steel Works (JSW), which manufactures a number of components for nuclear power plants for such customers as Areva and Toshiba, is seeking to attract additional customers for its production capacity so as to compensate for the severe impact on their business from the Fukushima disaster.

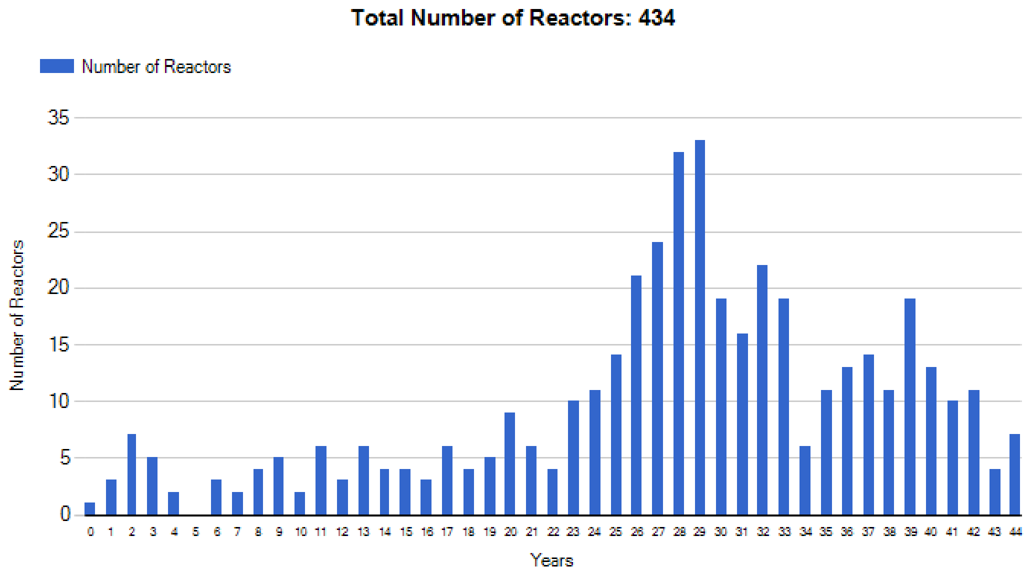
According to its president, Mr. Ikuo Sato, JSW is to dedicate itself to making gas and wind turbines in the near future. Nuclear components accounted for around 20% of the company's sales revenue.

In 2011, up to the month of November, after the accident at the Fukushima nuclear reactor plants occurred on 03/11/2011 in Japan, 13 plants were shut down, being 4 in Japan (disaster-hit), 8 in Germany (political reasons) and 1 in England (end of useful lifetime).

Up to August 2013, according to the IAEA, 82.7% of the operating reactors (359) around the world had been active for more than 20 years. Of these, 183 units had between 20 and 30 years, and 176 have more than 30 years of activity. Such fleets will have to be replaced by new reactors or by another energy generation source. Part of the solution is to extend the existing plants' useful lifetime, pushing the problem of energy supply on to the future. According to the WNA, by 2030, 143 are expected to be closed, as they will reach the end of their useful lifetime.

Mesmo após o acidente da usina de Fukushima muitos países continuam considerando a fonte nuclear como uma opção às mudanças climática e à instabilidade dos preços dos combustíveis para geração de energia elétrica. A expansão da geração nuclear depende também que governos ajam com responsabilidade e se comprometam com os critérios de segurança de operação de suas centrai.

Even after the accident at the Fukushima nuclear power station in Japan, many governments consider the international expansion of nuclear energy an option to climate change and an alternative to oscillations in the prices of energy products, and a protection against the uncertainties of fossil fuel supply. The worldwide expansion of nuclear energy requires that governments act responsibly and enforce strict safety criteria on the operation of nuclear facilities.



Age of Reactors in operation
Source: IAEA August 2013

IV - Current Situation of Nuclear Energy in Some Countries / Regions

A - Americas

Nuclear Power plant position in North America

A1 – North America

Canada

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Canada	19	14325	0	0	90,984	15,29

Canada's total nuclear installed capacity up to 2012 was 13,553 MW. The sources comprising a mix of hydro, thermal and nuclear sources, in addition to others such as wind, biomass, biogas and solar. Canada has 19 operating nuclear power plants (17 of them in Ontario) which generated 90.984 TWh or 15.29% of the country's electricity in 2012. All reactors are the PHWR type (pressurized heavy water reactor).

In September 2012 following a process of refurbishing and reconnection of Bruce Power Plant (4 PHWR Units), the Bruce-2 (772-MW) was synchronized to the grid. The plant located in Ontario returning to service after having been shut since 1995. Unit 4 was restarted in late 2003 and unit 3 in early 2004. The Unit 1 is expected to return to service the fourth quarter of 2012. Now they have 19 units in operation in Canada, with a total capacity of 14,325 MW. The Point Lepreau plant is also being refurbished and in October, 2012 it was grid-reconnected.
The long-term energy plan published in November 2010 contemplates at least two new nuclear plants (total capacity 2,000 MW) in the Ontario region (Darlington, where four other plants already exist) and refurbishing other 10 by 2020.

In June 2013 the Ontario Power Generation (OPG) has received detailed construction plans, schedules and cost estimates for two potential nuclear reactors at Darlington in Ontario.

The proposals were by Westinghouse Electric Canada (AP1000) and SNC-Lavalin Nuclear / Candu Energy. Completed submissions will be reviewed by a team of OPG and the Ministries of Energy, Finance and Infrastructure Ontario. The Nuclear Safety Commission of Canada has also granted a license to prepare the site, but no work was done on site.

The Canadian Nuclear Safety Commission has renewed the operating license for Ontario Power Generation's Pickering A and B stations, comprising six units, for five years, through August 31, 2018.

In 2013 Alstom has been selected to refurbish four steam turbine generator units of 3,512 MW Darlington power plant in Ontario, with an approximate power capacity of 900 MW each, for Ontario Power Generation's (OPG). This long-term service contract is worth approximately €265m (US$340m). Alstom will refurbish four steam turbines and generators units, and the associated auxiliary equipment. The first planned outage to start this modernization is scheduled for the fall of 2016 and completion of the entire refurbishment project is expected in late 2024. This mid-life refurbishment will be one of the largest capital infrastructure projects in Canada, creating significant long-term benefits for 25 to 30 additional years beyond the existing life cycle.

In 2011 Canada became the first country to announce it would withdraw from the Kyoto protocol on climate change since it will not able to reach goals because the exploitation of oil reserves in Canada and North America could increase global atmospheric CO_2 levels by as much as 15%. As the country is the largest supplier of oil and natural gas to the United States and is keen to boost output of crude from Alberta's oil sands - also known as tar sands - which are central to Canada's energy strategy.

The AECL develops the Advanced Candu Reactor (Generation III), fueled by enriched uranium or thorium, but there are no built units using such design.

Canada has its own reactor design (CANDU) partly backed by the government, which recently (May 2010) decided to withdraw from the business, after having allocated nearly 2 billion dollars to company AECL for developing the CANDU's new generation, since 2006. Such decision is due to the size of the AECL reactors division, not big enough to compete in the market with such giants of the size of AREVA or Toshiba and General Electric.

Specialists have vowed that, without the participation of the Canadian government, it would be difficult for the CANDU technology to survive; but in June 2011 the SNC-Lavalin Group signed a purchase agreement for taking up the government's share in the AECL reactors division. Of vital importance both in Canada and worldwide, the National Research Universal Reactor – NRU, located on Chalk River between the Quebec and Ontario provinces, is operated by the Atomic Energy of Canada Ltd - AECL, and produced – for some time – half of the world's medical isotopes. On account of maintenance problems associated with electrical flaws and heavy water leaks, it was shut down on 05/14/2009.

NRU at Chalk River – Canada (photo AECL)

Necessary corrective and maintenance work was performed for fifteen months. On August 17, 2010, after the repairs, the regulatory body authorized the reactor to be restored into service and the resumption of world-level production of radioisotopes. On October 2011, the NRU reactor, which also produces neutron-based nuclear research materials, was given authorization to continue radioisotope production up to 2016. Such facility is the world's oldest of its kind and has been in operation since 1953.

Canada is one of the largest uranium producers in the world. The company Cameco owns several mines whose production is exported to many countries. As an example we can mention the cooperation agreement signed with India for supply of Indian NPPs, which entered into force in 2013.

Nuclear wastes

Canada contemplates a Deep Geologic Repository (DGR) for low- and intermediate-level radioactive wastes. Site clearing and construction work and operation are proposed for the Tiverton region near the site of Bruce nuclear power station. Such nuclear wastes storage facility is planned to serve all nuclear power reactors at the Bruce, Pickering and Darlington power stations.

In 2007, after reviewing the options, the Canadian government decided that all of its spent fuel would be sealed into safe containers and stored in underground rock repositories for use in the future. Such facilities will be a megaproject with planned expenditures of the order of 20 billion dollars over an area of 10 hectares on the surface and galleries 500 meters below ground level.

Eight communities have expressed interest in the project, with three being in the Saskatchewan (Pinehouse, Patuanak and Creighton) regions and five in Ontario. These communities are in the learning stage with respect to nuclear wastes, which may be a heritage for future generations to use new nuclear technologies in recovering and recycling fuel expected to be developed over the forthcoming 100 years.

Canada's regulatory body - Canadian Nuclear Safety Commission (CNSC) worked out a plan of action for operators of any nuclear facilities in Canada to get them to review their safety stances and criteria in the light of the Fukushima events, with emphasis on defense-in-depth principles and mechanisms for prevention and mitigation of consequences from adverse and severe events in general. Under the plan, such external risks as seismic events, floods, fire, hurricanes, etc. must be considered and emergency plans updated.

The revitalization plans for Bruce power station's units (in Ontario) continue within the same established schedule, noting that Unit 2 is expected to be back in operation by late 2011 and Unit number 1 by early 2012. The final cost will be US$ 5 billion. Work activities on the remaining 6 plants are to start by 2015.

Mexico

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Mexico	2	1640	0	0	8,412	4.7

Mexico has a nuclear power station with 2 BWR operating plants (Laguna Verde-1 and -2, 820 MW, each) located in Vera Cruz, whose electricity production in 2012 was 8,412 TWh or 4.7% of the country's electric power. The power station's owner and operator is the state-run entity Comision Federal de Electricidad (CFE) which holds around 2/3 of the Mexican power grid's installed capacity, including transmission and part of the distribution network.


Laguna Verde – Mexico
(Image Comision Federal de Electricidad -CFE)

The long outages for 20% power uprate and other maintenance activities, completed in August 2010 on the two plants (Laguna Verde-1 and -2) brought down the percent share of nuclear energy in the country's total electricity generation.

Mexico has plans to build new plants over the forthcoming years, the first one to be on the grid by 2021. The future (ten planned) plants are reported to be 1,300 and 1,600 MW, using technology yet to be defined.

South Korea has plans to participate in this Mexican development through agreements and joint ventures inasmuch as Mexico intends to reach 35% capacity in clean energy by 2024 (nuclear new-build included). The country also has research reactors and has signed a cooperation agreements with Canada in the area of research and development.

The electricity mix is well diversified, with gas supplying approximately 49%, oil 20%, coal 12.5%, hydro 10.5% and nuclear 4.7% in 2007, according to data from the WNA. Per capita energy is around 1,800 kWh/year. Mexico is the world's seventh largest oil exporter, but has no uranium mines in operation.

All nuclear fuel in Mexico is property of the government, which is also responsible for waste management. In the case of the Laguna Verde power station, the waste is being stored on the plants' own site.

Jose Antonio Meade - Mexico's Secretary of Energy, Javier Duarte - Governor of the Veracruz State (where Laguna Verde-1 and -2 are located), and representatives of the Comisión Federal de Electricidad, together with technical staff members of the Comisión National de Seguridad Nuclear y Safeguards (CNSNS) conducted a general inspection on the two Mexican plants. Their report held that the nuclear power station's operating conditions called for no major precautions and that nuclear energy in Mexico has a promising future; still, no plans exist to actually build a new nuclear plant in the near future.

According to the Secretary, nuclear technology has been functioning smoothly in Mexico, in spite of the country's history of earthquakes which, he argues, can be tackled with feasible technical solutions, stressing that it is more difficult to deal with the matter from the policy's perspective of the issue.

The Energy Minister Jordy Herrera is recommending expanding nuclear capacity as part of its strategic energy plan through 2026. Due to the country's rising gas reserves and its lower prices, the nuclear option is now less attractive and it will be delayed for over than three years

The Mexican congress backs nuclear technology in varying levels, depending on the political party.

United States

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
United States	100	98,560	1	1.180	769,331	18.97

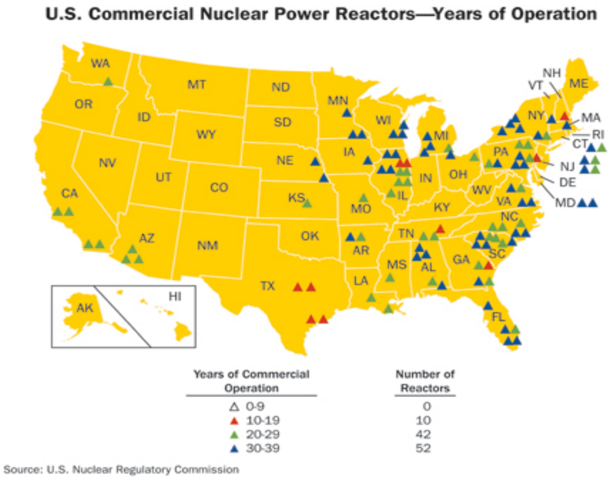
The United States are the owner of the world's largest nuclear fleet, with 104 plants in operation (69 PWRs and 35 BWRs), which correspond to an installed capacity of 107,714 MW in 2012; and in 2012 they produced 769,331 TWh(e). This figure corresponded to more than 32,8% of the world's entire nuclear energy and around 19% of that country's energy. Such amount is also approximately 70% of the electricity generated without greenhouse gas emissions.

The US has a total installed nuclear capacity of 98,560 MW as of June 2013 with 100 units in operation, after the permanently shut of 4 reactors in 2013 (Kewaunee in Wisconsin; Crystal River-3 in Florida and San Onofre-2 and -3 in Southern California) due economic situation.

The resumed construction of the Watts Bar-2 plant in Tennessee (PWR 1,160 MW) currently employs 3,300 workers of the TVA Co. (Tennessee Valley Authority Company). Project was experiencing cost overruns and schedule delays, but the delivery of the nuclear fuel from Westinghouse has already been authorized by the NRC and start of operation is planned for 2015.

The beginning of 2013 was by the start of construction of the first AP1000 models in the United States with **plants Vogtle 3 and 4**, in the state of Georgia, the first new American units in more than 30 years. They are scheduled to come in operation in 2018 and 2019 respectively. It follows in this context of new construction the two new units in **Central Summer** with two (2) AP1000 reactors (operator SCE & G), in South Carolina the first to go into operation in 2017 and the second in 2019. Thus we have until June 2013 five new reactors under construction with gross installed capacity of 6,218 MW.

In the United States, the installed capacity has been growing significantly in recent years due to the capacity expansion of nuclear plants, which figure reached 6.862 MW in May 2013, although no new unit had been built. This represents more than fourfold the future Angra 3 plant (1,405 MW) under construction in Brazil. In this process, some plants have come to increase their power output on several occasions, and 148 applications have already been reviewed. As the NRC reported in July 2013, an additional 14 requests (1000 MW) are pending review and other 3 may add 180 MW to the grid by 2017.



Welding at Watts Bar 2 Steam Generator

Position of American Nuclear Power plant in operation
http://www.nrc.gov/reactors/operating/list-power-reactor-units.html

Mention should also be made of the selection program for the siting of new nuclear power plants in the United States ("Nuclear Power 2010"). In this connection, there exist 30 new plants in the licensing process, with their COL (Construction and Operation License) under review by the licensing body – the NRC.

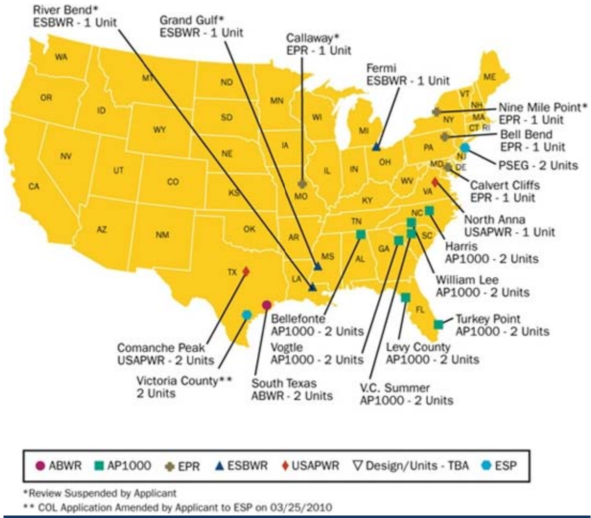
Another relevant fact to be underlined is the increase in the plants' useful lifetime, which is being extended to 60 years. In this case, **73 units** now have their useful lifetime extended, which is equal to **66,735 MW** functioning for more twenty years, with no capital costs involved in construction. In addition, the NRC – Nuclear Regulatory Commission is reviewing lifetime extension applications for 18 plants, and for an additional 9 others that have already started the application process but have yet to complete the submission of all relevant documentation. From this viewpoint, over the past recent 10 years, the United States have added a capacity equivalent to more than 30 new large reactors operating for 40 years.

On August 18, 2011 TVA's board approved the resumption of construction of Unit 1 (1260 MW - PWR) of Central Bellefonte in Alabama Work on the Bellefonte reactors was suspended in the 1980s when unit 1 was 90% complete and unit 2 was 58% complete. The construction was halted due to the drop in energy demand and costs. The current estimated cost is 4.9 billion dollars. The reactor is a PWR manufacturing Babcock & Wilcox and AREVA has been already contracted for engineering services and construction. The plant works are at about 50% complete should be completed between 2018 and 2020, and the current works only start when the fuel Watts Bar-2 (currently under construction) is loaded, not to accumulate construction of two plants simultaneously. Are already working on this project 300 employees of AREVA, all based in the United States. Another American concern is fuel supply for its nuclear fleet. In this connection the NRC has authorized the operation (June 2010) of the additional cascades of Urenco's New Mexico enrichment plant. This is the first U.S. enrichment plant using the gas centrifuge process.

In 2012 some 48 million pounds or 83% of the total uranium purchased by US nuclear power plants was of foreign origin, according to figures from the US Energy Information Administration. In addition, over a third (38%) of the enriched uranium needed to fabricate fuel for US reactors was supplied by foreign enrichers.

In 2012, 84% of foreign-supplied uranium came from Canada, Russia, Australia, Kazakhstan, and Namibia. The rest came from Uzbekistan, Niger, South Africa, Brazil, China, Malawi, and Ukraine, EIA said. Also 2012, a total of 52 million pounds of uranium hexafluoride (UF6) was delivered to enrichers in China, France, Germany, Netherlands, Russia, United Kingdom, and the United States. Enrichers in the United States received 62% of the deliveries, and the remaining 38% went to foreign enrichers.

Central de Vogtle3
http://www.southerncompany.com/what-doing/energy-innovation/nuclear-energy/gallery/images/_highRez/RW5_3261_wText.jpg



Localização aproximada das futuras usinas nucleares americanas
(http://www.nrc.gov/reactors/new-reactors/col/new-reactor-map.html)

In 2012, the average price per SWU (separative work unit) was $141.36, and owners and operators of US commercial nuclear power reactors purchased enrichment services totalling 16 million SWU, EIA said. This represents a total cost to the owners and operators of US commercial nuclear power reactors of about $2.3 billion.

Plans also include using mixed uranium and plutonium oxide fuel withdrawn from dismantled nuclear warheads (there exist around 7 tons of plutonium available for such purpose), and tests are under way at the Browns Ferry plant owned by TVA, which has been subsidized by the U.S. Department of Energy (DoE) for using such material on its nuclear power plants.

The U.S. Government foresees a 50 GW increase in the nuclear share of electricity generation by 2020, and Obama administration has announced a strategic plan to boost the restart of the nuclear industry, with government-backed loan guarantee being one of the facilities of that plan.

The plan contemplates loan guarantees in the amount of US$ 54 billion, following the commitment assumed by President Obama who asked Congress to pass a comprehensive bill on electricity generation and climate change (whereby a 28% fall in greenhouse gas emissions is expected to occur by 2020), with incentives for clean energy to become profitable.

Arkansas Nuclear One Generating Station Courtesy: Entergy Nuclear

The U.S. Government says power plants burning coal, oil and gas are the largest major source of emissions in the US, together accounting for roughly 40 percent of all domestic greenhouse gas pollution. The US will make continued progress in reducing pollution from fossil fuel power plants by leading the way in the development of clean energy technologies such as efficient natural gas, renewables, clean coal technology and nuclear, a climate action plan released by the White House says.

The accident of Fukushima seems not to have much affected the people's mood in the United States; rather, it has just boiled down to safety reviews that reportedly all concerned countries are conducting. Results of opinion polls of residents living near nuclear power plants showed that respondents continued to be much in favor (80%) of nuclear plant activities. Out of the population in general, 67% of the Americans consider the safety of the country's nuclear power plants as high. Such figures are expected to grow even more favorable upon the release of the report from the NRC and the Sandia National Laboratories (under evaluation by independent auditors) with a new mathematical approach to radiation dissipation on American nuclear power plants in case of reactor core melt-down. The data shows much lower radiation rates (of the order of 30 to 1) to the environment and the public in general, being estimated to concentrate on the plant's area.

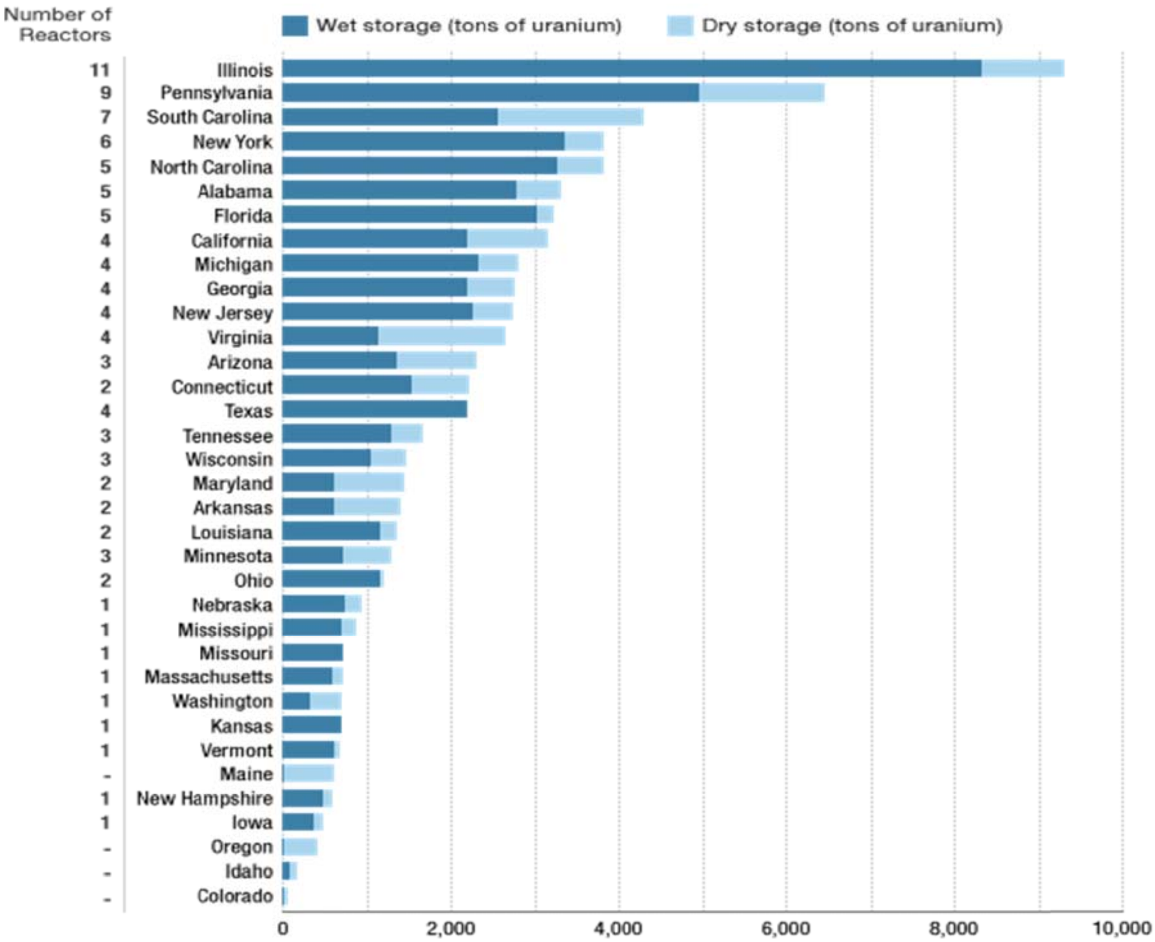
Potential sites exist in the US for 515 gigawatts of large nuclear power plants and 201 GW of small plants, the Electric Power Research Institute said of a study it released February 27. Oak Ridge National Laboratory said in its study, which was funded by EPRI, that 25 states could each "support siting at least 10 GW(e) in large reactor facilities with no siting challenges." A "large" nuclear power plant was defined as having a nominal capacity of 1,600 MW, and a "small" plant as having a capacity of 350 MW, representing a small modular reactor or a "cluster of small reactors," the study said.

Construction and pre-construction for new reactors are under way on 5 sites, it being expected that the installed capacity will surpass the 101 GW by 2010 and reach 109 GW by 2020. Another example is the agreement signed by Babcock & Wilcox Company and TVA, where plans are defined for the design, NRC licensing and construction of up to 6 modular reactors (SMR-Small Modular Reactor) on the Clinch River site - Roane County, by 2020. According to the president of the Lacy Consulting Group (Bruce Lacy), the biggest challenges for nuclear power in the U.S. continue to be the construction time, financing costs, and the competitive gas price.

Nuclear wastes

The United States has forecast a large definitive repository for the disposal of high-activity radioactive wastes that would meet, and guard of the fuel used in power plants to generate electricity, all the fuel used by the reactors of submarines, aircraft carries, and any other civil or military installation with nuclear reactors. This repository would be in Yucca Mountain, Nevada. In

2010, the NRC decided to abandon the project (after spending more than $ 9 billion). The NRC has determined that such waste can be stored safely in their own place of power plants for at least another 60 years after the end of the useful life time of the plant . In August 2013 the Court of Appeals for the District of Columbia ordered the NRC to resume the review of the abandoned license application to build and operate the nuclear waste site at Yucca Mountain, as requested by the DoE. With this is still pending the decision of how and when the country will solve the issue of its nuclear waste. The American government policy may be heading for reprocessing of irradiated material.



High activity waste stored at Nuclear Power Plant U.S. by state

The president of the Nuclear Energy Institute - Marvin Fertel made public some studies indicating there are no prospects for a greater increase in costs for new nuclear plant construction in the United States following the Fukushima disaster, inasmuch as the conditioning factors from the September 11, 2001 terrorist attack had already brought safety modifications into the nuclear industry, which had to install several physical barriers and modifications to nuclear power plants.

Note:

1 -Separative Work Unit **(SWU)** stands for the effort necessary to separate U235 and U238. It is measured in kilograms of separative work (kg SW).

A2 – South America

Location of South American Nuclear Power plant in operation

Argentina

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Argentina	2	935	1	692	5,902	4,7

Argentina has 2 operating nuclear power plants (Atucha 1- PHWR, 335 MW and Embalse PHWR, 600 MW), whose electricity production in 2012, was 5.9 TWh or 4.7% of the country’s electricity grid. On the same Atucha 1 site, nearly 100 km away from Buenos Aires, Atucha 2 - PHWR, 692 MW is under construction. Embalse PHWR is supplied by Canada (CANDU design) and Atucha-1 and -2 are supplied by Germany (KWU/Siemens and successors). Construction work on Atucha-2 began in 1981, were suspended in 1987 and resumed in 2006. Completion was reached in September 2011 and the plant is in the pre-operational testing phase, expected to be completed in the second quarter of 2013.

Jun 14, 2012 - Argentina's Neuquen plant has completed production of 600 mt of heavy water for the initial load of the Atucha-2 PHWR, the country's Planning Ministry has informed.

In August 2011, the government of Argentina signed an agreement with Canada (SNS-Lavalin-Candu Energy) for activities to expand by more than 30 years the useful lifetime of the Embalse plant, which started commercial operation in January 1984. Seven agreements in the amount of 444 million dollars are involved (US$ 240 million financed by Corporação Andina de Fomento-CAF), comprising transfer of Canadian technology and development of the local industry for nuclear component fabrication. The project’s total cost is US$1.366 million (noting that the difference will be allocated for contracting on the Argentinean market). In addition, there are plans to upgrade the plant’s generating capacity. Along this line, in August 2010, Canadian L-3 Mapps was engaged the supply a full-scope operator training simulator for Embalse, a development associated with the planned expansion of the plant’s useful lifetime.

In addition, the country, in advance of starting an international competitive bidding process, is holding contacts with several suppliers (Canada, France, Russia, China, Japan and USA) intended to define the technology and/or time schedules for two additional nuclear power reactors, one of them probably on the Atucha site.

The Rosatom Co. said on October 10, 2012 that it will "definitely" participate in a tender to build Argentina's Atucha-3, Kirill Komarov, deputy director general for development and international business at the Russian state nuclear corporation.

The country's policy of energy mix diversification has strongly reduced the oil dependence that prevailed in the 1970's, down from 93% to 42% in 1994 and currently standing at around 52%.

Aparência do Reator CAREM desenvolvido pela INVAP (Imagem: Invap)

http://www.invap.net/nuclear/carem/desc_tec.html

In this context, at the Province of Formosa the construction is planned of the Small Modular Nuclear Reactor CAREM (*Central Argentina de Elementos Modulares*), an Argentinean design prototype reactor proposed by technology company INVAP. Such plant is capable of being used as an electricity generator (27MWe), a research reactor with up to 100MWt or a desalination plant with an output of up to 8 MWe in co-generation mode.

As reported by the Minister of Defense Nilda Garré in June 2010, there are also plans for the construction of a nuclear-powered submarine using the same modular technology, which could be brought into operation as early as 2015 (5 years before the Brazilian project).

Energy exchange, mainly with Brazil, occurs according to each country's availability for input supply.

Operators from Atucha-1 are trained on Eletronuclear's simulator at Mambucaba - Angra dos Reis and those from Embalse are trained on Hydro-Quebec's simulator at Gentille-2 nuclear power station in Canada.

In May, 2013 was signed the agreement between Argentina (INVAP) and Brazil (CNEN) for the construction of the research reactor RMB (Brazilian Multi-proposal reactor). INVAP will supply basic engineering for the reactor that will be similar to the research reactor OPAL, in Australia.

Japanese accident and its consequences are being carefully examined and compared against plant designs in Argentina as part of the process of continuous improvement, as informed by the national regulatory body Autoridad Regulatoria Nuclear Argentina (ARN), which is considering the adoption of any change it may deem appropriate. In view of their location, Argentina's plants are not subject to the events that hit Japan, according to the ARN.

In August 2011, the Argentinean government signed a contract with Canada (SNS-Lavalin-Candu Energy) for activities designed to extend Embalse's useful lifetime by an additional 30 years.

Brazil

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Brasil	2	1,990	1	1,405	16,086	3,2

Brazil is the world's tenth largest energy consumer and eighth economy in terms of Gross Domestic Product, being the second not belonging to the OECD, just behind China.

Brazil has two nuclear power plants in operation (Angra-1, PWR, 640 MW and Angra-2, PWR, 1350 MW) whose electricity production in 2012 was 16.086 TWh or 3,2% of the country's electric Power, and one plant under construction (Angra-3, PWR, 1405 MW), whose construction work started in 2010, following extensive negotiations with the Angra dos Reis town hall in connection with the soil use license and the environmental-social compensation plan, whose investment amount comes to 317 million reals (around US$175 millions).

Angra 3 – status of construction (Aug 2013) Reactor Building (photo Eletronuclear)

On September 28, 2013, it was 13 years since the Angra-2 plant reached 100% of its rated power. The plant's electricity production in that period was more than 115 million MWh. Such amount of electric power would be enough the supply the city of Rio de Janeiro for nine years; Sao Paulo, for six; and Brasília, for more than two decades. The operation is foreseen for 2018.

The country's electricity production is primarily supplied by hydropower; such generation accounted for more than 90% of the total in 2012. A strong economic growth is expected until 2030, and accordingly, a large increase in electricity consumption. Besides the construction of power plants with other fuel sources, plans to diversify Brazil's electricity mix (as per data from the energy research entity *Empresa de Pesquisa Energética - EPE*) contemplate the construction of 4 to 8 nuclear power plants within a time horizon up to 2030, located in Northeast and Southeast Brazil. Site definitions, reactor types and other matters are under study at Eletrobras Eletronuclear and EPE.

In terms of fuel in Brazil, estimates of Santa Quitéria reserves (Ceará) come to 142.5 thousand tons of uranium. Also in operation is the Caetité mine (Bahia), whose production capacity is being expanded. Prospecting the Brazilian territory is the challenge yet to be met, but the prospects are promising.

Brazil also has four research reactors, two in Sao Paulo State, one in Minas Gerais State and one in Rio de Janeiro State. The largest of them produces radioisotopes for use in industry and in medicine. Among the different medical applications of these elements, mention is made of markers in diagnostic examinations those for treating tumors. Brazil is not self-sufficient in radiopharmaceuticals, importing part of what it needs, mainly molybdenum-99. The supply is currently uncertain, with only three major producers: Canada, Netherlands and South Africa. Argentina can also supply this material for Brazil, reaching as much as 30% of Brazilian requirements. The Brazilian Multipurpose Reactor-RMB, currently in the conceptual design phase, will be located at Iperó Village, beside the Aramar Experimental Center, will be a solution to this problem, according to CNEN.

In September 2010, the International Atomic Energy Agency (IAEA) approved the proposal from the Radiopharmaceuticals Division of Instituto de Engenharia Nuclear (IEN), in Rio de Janeiro, to study the feasibility of an alternative, more cost-effective method for production of iodine-124. Such radioisotope has been under research in several countries for use in positron emission tomography (PET), considered to be the most advanced imaging exam currently available.

In the area of specialized personnel training, the University of Sao Paulo - USP will be creating by 2012 (classes to start in 2013) a nuclear engineering course in the area neighboring the RMB. This is the second nuclear engineering course at a public university in Brazil, the first one was created at the UFRJ in 2010. Such courses cover nuclear technology as a whole, and not only nuclear engineering. UFRJ’s COPPE also offers a graduate course [*British terminology, post-graduate*] in nuclear engineering. The Federal University of Pernambuco (UFPE) provides a course in energy studies, which also addresses the nuclear part of electricity generation.

Brazil and Argentina in 2011 decided to expand their nuclear cooperation agreement signed in 2008 to include the construction of two research reactors. These will be the multipurpose type and used for radioisotope production, fuel and material irradiation tests, and neutron research.

In July 2012 was initiated the basic engineering project of the Brazilian Nuclear Submarine Propulsion - SN BR. This basic design should take three years, after which begins the phase of detailed design, together with the construction of the submarine in 2016, in the Navy yard being built in Itaguaí (RJ). The contract is about 21 billion reals (10,2 billion dollars). The completing construction for the experimental operation of the reactor and its nuclear propulsion plant (LABGENE) is estimated for 2014. The completion of the construction of the first SNBR is planned for 2020.

Brazilian government approved in August 2012 a plan to set up a state-owned company to oversee production of the country's first nuclear submarine. The company, Blue Amazon Defense Technologies or Amazul, will be in charge of "promoting, developing, absorbing, transferring and maintaining" technologies needed for Brazil's nuclear program and nuclear power-related activities of the Brazilian Navy, including the construction of Brazil's first nuclear-powered submarine. Amazul will also help create new companies in Brazil's nuclear sector, offering them technical assistance if necessary. The sub is currently under construction in Itaguaí, Rio de Janeiro State, and Amazul is to be headquartered in Brazil's largest city of Sao Paulo, also in the southeast. With respect to consequences of nuclear accident in Fukushima, after technical reviews the Brazilian’s Utility, Eletronuclear that construct and operates Nuclear Power Plants has begun actions to reduce any risks which the domestic nuclear plants could be subject to in the event of a severe accident.

On the basis of the current knowledge, an event similar to that in Japan could not occur in Brazil because of its location, far away from the edges of the tectonic plate underlying the Brazilian territory; the South Atlantic plates move apart from each other, whereas Japan's tectonic plates collide with each other; and a South Atlantic type earthquake does not cause tsunamis.

Chile

Chile imports 70% of its power consumption, the greater part being produced from hydrocarbons. The country has two research reactors but no nuclear power plants. Studies have been developed to assess the possibility of building a nuclear generating plant; in addition, under cooperation arrangements with the IAEA, self-assessment programs are being conducted as a preparatory step for new constructions.

In February 2011, a nuclear cooperation agreement was signed with France, focused on nuclear training for Chilean scientists and professionals, including design, construction and operation of nuclear power plants. The agreement also includes uranium mining for supplying French reactors. The Minister of Mines and Energy, Laurence Golborne, declares that Chile will double its energy requirements over the forthcoming 12 years. The country has been trying to balance its sources of energy, which in the 1990's, was based on hydro power. Such sources need to be diversified mainly on account of the droughts occurred in past recent years (empty reservoirs) which caused instability in electricity supply. The natural gas solution failed to meet this need, and Chile is now looking to nuclear energy.

After the March accident in Japan, Chile has not changed its mind on nuclear energy and understands, as expressed by its president - Sebastián Piñera that nuclear energy and earthquakes are not mutually exclusive. This governmental position can be explained by the country's strong concern about energy shortage and by the experience gained with the operation of two research reactors (since the 1970's) which are used for medical studies. Such reactors resisted the strong earthquakes that ever hit Chile. New nuclear energy studies are going on.

Most of Chile's population does not support this position.

Venezuela

Although Venezuela has no nuclear power plants, the nuclear field is not entirely unknown to it. The Venezuelan Institute for Scientific Research (Instituto Venezolano de Investigaciones Científicas - IVIC) operated a 3MWt research reactor from 1964 to 1994 for the production of radioisotopes for industry, medicine and agriculture. In November 2010, the country's National Assembly ratified a cooperation agreement with Russia for working a research reactor and a power reactor. The agreement contemplates personnel development through training programs in safety, environmental protection, regulation, radiation protection and safeguards, but for now the country shows no other interests in nuclear energy.

B - Europe

Position of European Nuclear Power plant in operation

In the European Union as a whole, nuclear energy represents 30% of electricity supply. The nuclear policy differs from a country to another, and in some (for example, Austria, Ireland, Estonia) there is no nuclear generating plant in operation. As a comparison, France has a large number of plants in 19 different sites. Europe has no significant sources of uranium and 80% the European plants' feed material come from Russia, Kazakhstan, Canada, Australia and Niger.

The European Council has adopted a policy directive concerning the management of radioactive waste from any source as well as spent fuel, and requested member states to inform about their respective national programs set up to deal with the issue up to 2015. Countries will be required to define whether and how their wastes will be stored or reprocessed, how much will that cost, etc., and the "wait-and-see" postponement policy that has prevailed so far will no longer be acceptable. Countries could unite to find a joint solution, but this will have to be verified and approved by the IAEA. Moreover, exporting radioactive wastes to countries having no appropriate repositories or to African, Pacific, Caribbean countries, and to Antarctica will not be allowed. (http://ec.Europe.eu).

Europe has 196 operating nuclear reactors in 14 countries and many of them are seeking to extend their useful lives. After the Fukushima accident, the European Union (UE) through several entities established a safety assessment plan for nuclear power plants in the European bloc intended to preserve energy security. Tests began in June and consist of three phases:

1) pre-assessment by the nuclear power plant operator itself answering a EU questionnaire;
2) the answers are checked by the country's regulatory body;
3) a review is done by an international committee of experts.

The questions have to do with: ability to resist such natural disasters as earthquakes, tsunamis, floods or other extreme natural conditions; ability to withstand man-made events, whether by terrorism or neglect (blasts, airplane crashes, fire); and what preventive measures are taken to avoid and/or mitigate such events. There are 19 new reactors under construction in the continent. In June 2011, FORATOM, trade association for the nuclear energy industry in Europe, issued a study report to help establish in the continent the basis for a secure, competitive and low greenhouse gas-emitting energy mix over the coming 40 years. It concluded that whatever the scenario for achieving the low-emissions objective in such time frame, nuclear energy should be included in all electricity generation plans.

On October 4, 2012 The European Commission post-Fukushima report listed main recommendations for improvement of EU nuclear power plant safety, stemming from stress tests conducted. In its report to the European Council and Parliament was summarized results of 18 months of comprehensive risk and safety assessments at 145 nuclear power units in the EU, and outlined plans for follow-up actions. Nuclear power plant operators will have to spend a total of between Eur10 billion and Eur25 billion (currently $13 billion and $32.5 billion) to make safety upgrades recommended by the EU post-Fukushima reactor stress test and peer review process
The recommendations are the following:

- Nuclear site seismic analysis should be based on earthquakes with an occurrence probability of less than once in 10,000 years, taking into consideration the most severe earthquake over that period.
- The same 10,000-year approach should be taken for severe flooding.
- Seismic resistance should be calculated using a minimum peak ground acceleration of 0.1 g, and plant design must be able to withstand an earthquake producing that acceleration. This is a recommendation of the IAEA.
- Equipment needed to cope with accidents should be stored in places adequately protected against external events.
- On-site seismic instrumentation should be installed or improved.
- Plant design should give operators at least one hour to restore safety functions after station blackout and/or ultimate heat sink.
- Emergency operating procedures should cover all plant states.
- Severe accident management guidelines also should cover all plant states.
- Passive measures such as passive autocatalytic recombiners (H_2) "or other relevant alternatives" should be in place to prevent explosion of hydrogen or other combustible gases in case of severe accidents.
- Containment filtered venting systems should be in place.
- A backup emergency control room should be available in case the main control room becomes inhabitable due to radiation, fire or extreme external hazards.

http://ec.europa.eu/energy/nuclear/safety/doc/swd_2012_0287_en.pdf

Armenia

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Armenia	1	375	0	0	2,123	26,62

Armenia is an ex-soviet republic with around 3.2 million inhabitants. The country has one plant in operation - Armenia 2 (PWR, 375MW) and another one permanently closed 1989, after a earthquake.

In 2012 its sole plant in operation produced 2.123 TWh of electricity, which accounted for 26.62% of the country's electricity generation, that was 7.978TWh. Armenia is particularly dependent on Russia for trade and energy distribution, its only company was bought by Russian RAO-UES in 2005. The country has conducted the same safety tests as the EU nations, although not being a

member of the Bloc.
Natural gas is mainly imported from Russia, but the construction of a pipeline to deliver natural gas from Iran to Armenia was completed in December 2008, and deliveries of gas expanded in April 2010 after the completion of the Yerevan Thermal Power Plant.

Austria

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2011 (TWH)	% of total energy generated in 2011
Áustria	0	700	0	0	0	0


Nuclear Power Station Zwentendorf, Áustria (Closed)

Austria has a ready plant that never operated due to a population referendum with narrow decision (50.47%) where it was defined that the country would not use nuclear energy for electricity generation. Accordingly, the Zwentendorf plant (BWR-700 MW) was canceled in November 1978.
The design and construction companies were dissolved and the nuclear fuel supply agreements with EXPORT (USSR) and the U.S. Department of Energy (DOE) were canceled as well as the agreement for reprocessing of spent fuel with French COGEMA.

In Austria about 60 percent of electricity production is from domestic hydropower. It has oil and gas, but it is well-known that they use nuclear electricity from neighboring countries and it is estimated to be five to 10 percent of total consumption. Officially, nothing is said about that, but the country does use nuclear electricity buying it from Germany and the Czech Republic. They use cheap nuclear electricity or the night tariff to pump water to pump-storage high in the mountains during the night and use expensive, peak-load electricity from hydropower stations for their own consumption or for export to neighboring countries. It is a magic transfer from nuclear electricity to 'green' electricity, according to Prof. Helmuth Böck, president of the Austrian Nuclear Society.

Academic training in the nuclear area in Austria is a rather developed activity, with emphasis on nuclear knowledge management provided by the Atominstitute (ATI) which develops research, training and education programs on its Triga reactor

The country also hosts the International Atomic Energy Agency – IAEA's headquarters and units dedicated to training and education in the fields of science and technology.

Belgium

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2011 (TWH)	% of total energy generated in 2011
Belgium	7	6092	0	0	38,46	51,00

Belgium has two nuclear power stations, Doel with 4 plants (PWR, 2963 MW) and Tihange with 3 units (PWR, 3129 MW). The plants have been operating for 28 to 39 years and are licensed for 40 years. The Belgian Cabinet on July 4,2012 voted to extend operation of the three oldest plants Doel-1 (412-MW), Doel-2(454-MW) e Tihange-1 (1.009-MW) that have their useful lifetime extended for more 10 years, until 2025 (operation during 50 years).

45.942 TWh were produced by nuclear source in 2011, which accounted for 53.95 % of the country's electricity generation. The older plants - Doel-1 (412-MW), Doel-2(454-MW) and Tihange-1 (1,009-MW) extended the useful life for more 10 years, that is, up to 2025. At present, the policy to phase out all reactors up to 2025 is being severely questioned. Costs will be huge, bringing losses to security of supply, dependence on international sources, and increased emissions. This diminished the country's competitiveness, as indicated in the report - Belgium's Energy Challenges Towards 2030, which strongly recommends returning to nuclear electricity generation.

Anyway, the country's prevailing decision today is to shut down the oldest reactors by 2015 and the others by 2025, subject to the existence energy sources capable of meeting electricity requirements without imposing rationing programs on the population. Operators GDF Suez and Electrabel jointly with energy-intensive consumers (chemicals, gases, plastics, specialty metals) united to try to keep power plants operational for the longest period possible. Their plans also contemplate investing in the construction of a new nuclear plant following the Finnish model, in which consumers get together to build their power plant (Olkiluoto model).

In the research area, the government approved a resolution in March 2010 authorizing use of resources of the future research reactor Myrrha (Multi-Purpose Hybrid Research Reactor for High-Tech Applications) for development of innovative solutions in energy and nuclear medicine. The reactor and accelerator have been designed by SCK-CEN that has awarded a €24 million ($32 million) contract for front-end engineering design for the Myrrha accelerator-driven research reactor to a multinational consortium led by Areva in October 2013. The others are Italy's Ansaldo Nucleare and Spain's Empresarios Agrupados.

That reactor would be used, for example, in treating nuclear wastes through transmutation; modifying the characteristics of semiconductors (doped silicon) essential for applications in electronic components, etc. A large-capacity factory is yet a long distance away, but a pilot project (at the cost of 1 billion euros) is planned to be commissioned by 2019 at the Belgian Nuclear Research Center-SCK, as part of the Myrrha project. The tests will take 5 years until the start of commercial operation, but may lead to a significant reduction in the amount and size of permanent storage facilities for high-level radioactive wastes.

The stress test results have been satisfactory and on November 8, 2011 the regulatory body said that the Belgian plants are safe and may continue in operation.

The Belgian minister of energy stated that the decision on extending the lifetime of the country's plants will not be taken until after the results of current stress tests for all nuclear power plants in Europe are released.

In a pool on 27/02/2012 the Forum Nucleaire's shows that 76 percent of Belgians would be in favour of continued production of nuclear energy, and 40 percent would support the building of new power plants in order to ensure energy supplies. With the condition of plants safety and the proper management of nuclear waste are guaranteed.

Bulgaria

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Bulgaria	2	1.906	0	0	14,86	31,65

Bulgaria has 2 nuclear power plants (KOZLODUY 5 and 6 – VVER-PWR 1000 MW, each) in commercial operation, which accounted for 14.86 TWh, approximately 31.65%, of electricity generation in 2012. The construction of the two plants that were under construction (Belene 1 and 2 VVER PWR 1000 MW) was suspended and there are 4 reactors shut down (KOZLODUY 1 to 4 – VVER 440 MW) to comply with the European Union energy agreement. Bulgaria's government has already expressed interest in replacing old nuclear power plants with new ones, though finance is lacking.

NPP KOZLODUY

Bulgaria's NEK - National Electric Company holds 51% in the nuclear power plant project at Belene (2x 1000 MW – VVER) and signed a contract with Russia's Atomstroyexport for design, construction and commissioning of the plant's units, but the price is above what the country accepts to pay, which would bring about construction contract performance delays. In March 2012 the government decided to use the equipment that had been manufactured for Belene in another plant in Central KOZLODUY (the reactor No. 7).

The results of safety stress tests performed all over Europe are under review and the relevant recommendations will be implemented where appropriate.

There is also a research reactor in the Institute for Nuclear Research and Nuclear Energy (INRNE) operated by the Institute for Nuclear Research and Nuclear Energy (INRNE) of the Bulgarian Academy of Sciences in Sofia.

Nuclear wastes

Bulgaria has awarded the design contract for a low- and intermediate-level storage facility to a consortium formed by Spanish ENRESA, Westinghouse Electric Spain (WES) and German DBE Technology. The repository will be built on the site of the Kozloduy plant.

Czech Republic

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Rep. Checa	6	3760	0	0	28,602	35,3

The Czech Republic is rich in mineral coal deposits and Europe's third largest exporter of electricity. The country has 6 plants (Dukovany 1 to 4 and Temelin 1 and 2, all VVER) operated by company CEZ, which produced 28,602 TWh in 2012, accounting for 35.3% of the country's electric power.

Temelín nuclear power plant (foto ČEZ)

In the Temelin site, which was originally designed for 4 reactors and but for political reasons only 2 were built, has now an international competitive bidding process on the supply of the two new reactors has been initiated, with suppliers from France (AREVA), U.S./Japan (Westinghouse) and Russia (Rosatom) trying to sell their products. Offers were received until July 2012. The winner would be announced in 2013, but Areva was disqualified by bid commission and it decided to appeal against the decision. So the final selection of the winner will be postponed for some months.

NPP Dukovany – Czech Republic ***(Image: Petr Adamek)***

In addition, an extension of the useful life time has been requested for the 4 reactors of Dukovany nuclear power station, which has been in operation for more than 20 years. This would enable the facility to generate electricity up to 2025 – 2028. The extension of plants' useful lifetime is estimated to require a significant amount of work and investment. The activities are planned to start by 2015 and will also contemplate power upgrade by up to 500 MW(e).

In June 2011 on request of the Czech government, the nuclear station Dukovany went through a safety inspection by the IAEA (Operational Safety Review Team - OSART) in, where it was found that the plant is safe, noting that some of its safety practices could be improved as recommended by the inspection team. The Czech government declared that will proceed with its plans for construction of new nuclear plants, so that the Czech Republic will rely on nuclear energy to generate half of its electricity by around 2040 – up from about one-third now under an energy policy adopted by the country's Cabinet as declared by national utility CEZ on November 8, 2012.

Dukovany nuclear power station's reactors will also be capable of supplying heat for their neighborhood, the town of Brno, 40 km far away, according to the environmental impact study submitted to local authorities by the operator. The population would benefit from carbon emission reduction and heating cost stability.

England and Northern Ireland (UK)

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2011 (TWH)	% of total energy generated in 2011
England	16	10,902	0	0	63,96	18,1

The United Kingdom has 16 plants in operation (9930 MW installed capacity) and 29 closed for having reached the end of useful lifetime or obsolescence. It is Europe's oldest fleet, with closed plants that started operation in the 1950's and 1960's. In 2012, the country produced 63.96 TWh of energy from nuclear source (18.1% of the total).

The United Kingdom has 75% of its electric power produced by oil and coal, and as a means to reduce its greenhouse gas emissions, the Government launched in July 2009 its Plan of Transition to a Low-Carbon Economy. The Plan is focused in transforming the energy sector by expanding the use of renewable sources, besides increasing the energy efficiency of the country's buildings, homes, and transport industry.

Power reactors planned and proposed					
Proponent	**Site**	**Locality**	**Type**	**Capacity (MWe gross)**	**Start-up**
EDF Energy	**Hinkley Point C-1**	**Somerset**	**EPR**	**1670**	**2018**
	Hinkley Point C-2		**EPR**	**1670**	**2019**
EDF Energy	**Sizewell C-1**	**Suffolk**	**EPR**	**1670**	**2020**
	Sizewell C-2		**EPR**	**1670**	**2022**
Horizon	**Oldbury B**	**Gloucestershire**	**ABWR x 2 or 3**	**2760-4140**	**by 2025**
Horizon	**Wylfa B**	**Wales**	**ABWR x 2 or 3**	**2760-4140**	**by 2025**
NuGeneration (Iberdrola + GDF Suez)	**Moorside**	**Cumbria**	**AP1000? x3**	**Up to 3600**	**2023**
Total planned & proposed	**Up to approx 18,600 MWe**				

Source: WNA

Accordingly, the country is expected to realize the domestic goals of cutting by 34% the greenhouse gas emissions until 2020, when 40% of electricity consumption in the United Kingdom are estimated to come from low-carbon sources, with renewable and nuclear energy, as well as carbon capture and sequestration technologies.
Building a new fleet of nuclear power plants is part of the carbon emission reduction policy existing in the country and such plants are planned to start operation by 2017, replacing the oldest nuclear facilities (the one that last started to operate dates back to 1989) and those already closed.

Company Horizon Nuclear Power - joint venture formed by E. ON UK and RWE AG, which was filing license applications for the Wylfa Peninsula and Oldbury sites was sold in October 2012 (most because political questions in Germany) and the new owner is Hitachi.

For the Hinkley Point site, where 2 old plants already exist, EDF has beginning the work for an EPR 1600 (Hinkley Point C), in the region of West Somerset and has placed orders with AREVA for such plants' heavy components. Applications for the three main environmental permits required to operate the proposed new UK nuclear power station at Hinkley Point C in Somerset have been given positive assessment by the country's Environment Agency, EDF has announced. and in December 2012 the British regulators approved the EPR project. The final investment decision was taken this project in October 2013. Besides the EDF, the consortium China General Nuclear Corporation (CGN) and China National Nuclear Corporation (CNNC), will have a combined share of 30% to 40% in the business consortium, and the French state-owned nuclear group Areva, with 10%. These two EPRs represent the largest investment in infrastructure project in England since the 1950s.

The expected is the power supply corresponds to 6% of the total in England (enough to serve five million homes).

Um group formed by Spain's Iberdola (37.5%), Britain's Scottish & Southern (25%) and France's GDF Suez (37.5%), set up a consortium - NuGeneration Ltd (NuGen) that acquired in 2009 a land plot in Sellafield (west England) as a possible site for new nuclear reactors. In this case, the Project involves the construction of a nuclear plant with an installed capacity of 3600 MW, to help achieve the goal of changing the United Kingdom's energy profile, which is strongly based on coal.

Hinkley Point C (illustration- WNA)

Reusing plutonium from civil nuclear facilities is a fundamental condition of the carbon reduction plan adopted by the U.K. which needs to manage 112 tonnes of material in storage (produced locally and from customers external to the Sellafield reprocessing plant). Although reuse through the production of MOX fuel, so far, is not so commercially successful in Britain as in France (AREVA), the produced material could feed 2 reactors for up to 60 years.
5/07/2011 - According to Britain's Minister of Energy and Climate Change, Charles Hendry, "The U.K. government remains absolutely committed to new nuclear power plants; without them, the nation would be darker and less prosperous".

"We need to maintain public confidence based on fact and scientific evidence and the existence of a strong independent regulatory body". He believes that nuclear energy today is vital to the British energy sector and will so remain for many years. The United Kingdom should have not just one plant built, but a fleet, and this requires that investors be given assurances in this regard.
The entire process is part of the country's low-carbon policy, incorporating any lessons from the Fukushima accident. On July 22, 2011 the Parliament approved the national energy policy and listed eight (8) sites for new nuclear power plants; also a plan was put forward to expedite such construction projects.

On 10/17/2011 the Secretary of Energy declared that nuclear energy risks are known and much smaller than the acceleration of climate change. U.K. population shows a high support for nuclear energy, with 61% of respondents agreeing on new constructions mainly as a means to prevent climate change and ensure energy security.

A majority (63%) of people in the UK think the government should increase the use of nuclear, according to the findings of a recent poll (October 2012).

In February 2012 The UK and France are to sign a landmark agreement in Paris to cooperate on civil nuclear energy, paving the way for the construction of a new generation of power plants in the UK. Deals between British and French companies – worth more than 500 million pounds (about 600 million euro) – will allow work to start on new facilities, creating more than 1,500 jobs.

The deals would include a £100 million contract with a construction consortium to prepare the Hinkley Point nuclear site in Somerset for construction of two European Pressurized Water Reactors (EPRs).; a £15 million training campus at Bridgewater in Somerset to train the next generation of nuclear workers and a deal with Rolls Royce for key components that could be worth potentially up to £400 million.

In June 2013 The UK government announced a bid to encourage investment in nuclear power by offering 10 billion pounds (GBP) (15.2 billion US dollars, 11.6 billion euros) of guarantees to investors in a new nuclear plant at Hinkley Point.

A recent poll among residents found that the Fukushima-Daiichi nuclear accident had virtually no impact on public attitudes to nuclear power in the UK

Nuclear wastes

The United Kingdom reprocesses nuclear wastes in its reprocessing plants at Sellafield. At present, the country's stockpile of Plutonium comes to 82 tonnes, and keeps growing. Talks are under way between the British government and GE-Hitachi about the possible use of Fast Breeder Prism reactor technology with a view to reducing the Plutonium stockpile by using it as MOx fuel, from 2025 onwards.

Finland

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Finland	4	2.780	1	1.720	22,066	32,59

Finland has 5.25 million inhabitants and four plants in operation which, together, account for the production of 22.278 TWh of electricity or 31.58% of the country's total electricity generated in 2011; in addition, a nuclear plant project is under way, Olkiluoto 3 – EPR 1600 MW. Due to the excellent performance of the 4 operating plants, nuclear plant availability over the past recent 36 months reached an average of 94.65%.

In 2011 Fennovoima announced that it had chosen Pyhäjoki, in northern Finland, as the site for the country's third nuclear power plant. Construction is expected to start in 2015.

There is a small research reactor located in Otaniemi, Espoo; a TRIGA Mark II, built for the Helsinki University of Technology in 1962.

As it decided, in 2002, for the construction of a fifth nuclear unit, Finland dispelled the situation that prevailed in West Europe, where it was a long time since proposals for new nuclear construction were presented.

Nuclear Power Plant Olkiluoto 3 (photo AREVA)

The importance of the Finnish decision lies on the fact that it was preceded by detailed analyses with public participation and extensive political discussions.
A decision was based on such aspects as environmental (smaller impacts on the environment), political-diplomatic in line with the international commitments from the Kyoto Protocol, and strategic aspects (lower dependence on other external energy sources, mainly from Russia, and

the long-term stability of the cost of nuclear energy). The highly favorable public opinion was another important driver of the decision.

Olkiluoto 3 plant (1,600 MW, EPR) is now scheduled to start operation in August 2014. It will be the first plant with the EPR reactor design created by French AREVA.
The Project is showing a delay of nearly 5 years vis-à-vis the original plan. The total cost will be "close" to the Eur8.5 billion.

Several problems (construction, licensing, subcontracting, etc.), arising from the fact that such plant is the first of a kind of new reactors, and that qualified, experienced labor does not exist in sufficient quantity in either Finland or the countries involved in the project would be at the root of the delays occurring so far.

Areva's estimated losses up to end of this Project come to 2.7 billion euros. Nevertheless, in July 2010, the Finnish parliament approved the country's 6th reactor (more than 1 reactor per one million inhabitants).

Out of the three companies that submitted environmental impact studies to the national authorities, Teollisuuden Voima Oy was chosen for an additional unit on the Olkiluoto site (Olkiluoto unit 4 – with no schedule or definition of technology, but with geologic studies in progress). Costs have been estimated in the range of 4 - 6 billion euros.

On Dec 07, 2011 TVO (Teollisuuden Voima Oyj) has today decided to commence the bidding and engineering phase of the company's fourth nuclear unit at Olkiluoto, Finland. According to the decision-in-principle, ratified by the Finnish Parliament in July 2010, the application for a building permit for the Olkiluoto's fourth unit must be filed latest in June 2015.

NPP Loviisa - PWR 488 MW, each (photo Fortum)

Fennovoima Oy also has construction approval from the municipalities involved, and plans to build 2 AREVA reactors (EPR 1700 MW) and one TOSHIBA design plant (SWR 1250 MW – BWR). With 4 site possibilities, it still awaits a forthcoming opportunity. Fortum (51% owned by the Finnish government) has plans for a new unit on the Loviisa site, and is awaiting possible authorizations.

The Finnish government decided to tax the profits of companies operating nuclear and hydro power plants to ensure operational competitiveness on the carbon market.

In June 2011, a power upgrade was completed at the Olkiluoto 2 plant. In July 2011, Fennovoima invited Areva and Toshiba to submit bids on the construction of Finland's new nuclear reactor. This is the world's first advertised competitive process for a nuclear new-build project after the Fukushima accident. Pyhajoki site preparation work on the Hanhikivi peninsula, northeast Finland, is expected to start by late 2012 and construction, by 2015.

NPP Olkiluotto (simulation with 4 reactors - AREVA)

Nuclear wastes

Finland was the first country to get its parliament to approve, in 2001, a deep underground repository for radioactive waste from nuclear power plants.

In Finland, low- and intermediate-level radioactive wastes are stored in underground repositories built at Olkiluoto (since 1992) and Loviisa (approved in 1992). Since 1997, in accordance with the Radiation Act, Finland maintains a central interim disposal facility located in the area of the Olkiluoto final repository, whose expansion has already been approved by the Finnish parliament.

For new plants storages are under discussion with the Posiva, responsible for this activity, better management of all new waste as determined by the government ensuring that the best solutions and economic security should be shared between the nuclear power plants. As Posiva is owned by Teollisuuden Voima Oy, or TVO, and Fortum, it is developing a final spent fuel repository for the two companies at the Olkiluoto nuclear power plant. Fennovoima, a newcomer to the Finnish nuclear industry, has no operating reactors and no plan for final spent fuel storage. It plans to build a 1,600-MW unit in northern Finland. The company is 34% owned by E.On, but E.On is trying to sell that stake.

Finnish nuclear power plants passed the EU stress tests and results showed that no major modifications to the Olkiluoto and Loviisplants will be necessary.

France

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
France	58	65.880	1	1.720	404,900	74,79

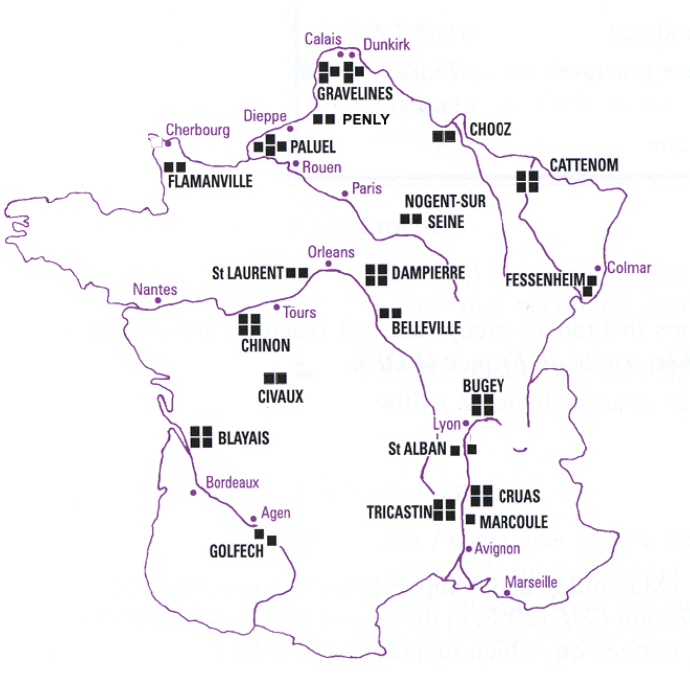
The country's total installed capacity is 123,001 MW and electricity production was 550.3 TWH. France has 58 operating nuclear power plants (on 19 different sites). Eleven plants on shutdown (useful lifetime over) produced 404.9 TWh, which represents 74.79% of the country's total generated electricity in 2012. EDF is the utility that operates the entire fleet. Among these, the Phenix plant is a research reactor.

With the population of 64 million, France has nearly one nuclear power plant per million inhabitants and more than 1,000 MW of installed nuclear capacity per such same million. The country is the world's largest exporter of electricity and earned in 2010 more than 3 billion Euros in this process.

France produces the cheapest energy across Europe, about half of the value of German power. Are 220,000 direct jobs in the nuclear area, or 6.1% of the country's manufacturing jobs scattered throughout the French territory.

The country is the world leader in recycling 25,000 t recycled at la Hague plant.
France's CO_2 emissions from electricity generation are around 70 to 80 g per kWh, compared with European average of 350g of CO_2 per kWh.

The French AREVA, supplier of nuclear products and services, is building jointly with EDF the Flamanville-3 reactor, EPR type, 1720 MW, located north of France, in the region of Manche. The other equipment and service suppliers were also defined and hired, and construction started in late 2007.



Location Map of France´s nuclear installations Source: WNA

Among the plants existing in France, 34 are of the 900MW-PWR class, the operation of which was declared satisfactory by the regulator (ASN) for up to 40 years' lifetime (French plants have an estimated operational period of 30 years), but each is required to go through a safety review to validate such lifetime license. Tricastin-1 (915-MW, PWR) was the first reactor subjected to review and authorized for more 10 years.

According to the RTE – the French grid operator, on account of the country's ageing generating fleet, as early as 2013 France is possibly expected to have supply problems during peak-load times if the plants' useful lifetime has not been extended. By 2022, 22 French reactors will reach the end of life and the country has few options for electricity generation than the extension of life of these plants. The coming on line of the new Flamanville-3 EPR type, 1600 MW reactor is deemed indispensable.

Maintenance operations to keep the fleet in order require advance planning and procurement. For example, for the planned exchanges of French plants' steam generators, 44 units have already been purchased at the cost of 2 billion dollars (32 to Areva and 12 to Westinghouse). The deliveries will reach as late as 2018.

In November 2012, The French Prime Minister Jean-Marc Aryault signed license of safety installation for ITER- International Thermonuclear Experimental Reactor. It also represents a global licensing first, being the first fusion device in history to have its safety characteristics scrutinised by a national nuclear regulator as part of the licensing process.

The work on ITER under construction in the region of Cadarache, southeast France, had its costs inflated, up from EUR 6 billion to Eur18 billion, over the past 3 years. The international financial crisis also affected the Project, the preliminary phase of which is now scheduled for 2019. Several countries are involved in the development of this project, including the U.S., Europe, Russia, China, Japan and South Korea, which is aimed at producing energy from nuclear source, but leaking no radiation above background levels.

Flammanvile - 3 (photo Areva)

In June 2008, the French government declared that an additional EPR 1600 reactor will be built, probably on the Penly site (Seine-Maritime) northeast France, where 2 operating reactors already exist. Of this same AREVA EPR reactor model, there exist 4 other units under construction (Olkiluotto 3 in Finland, Flammanvile 3 in France and Taishan-1 and -2 in China).

The President Francois Hollande's Socialist government, the new government elected in France in 2012, wants to implement its planned partial phase out of nuclear power, which forecast to cut nuclear power's share from 75% to 50% by 2025 and replace most of its capacity with renewable energy. According to a plan of French grid operator RTE the country will need to invest Eur15 billion ($19.2 billion) in the national transmission network by 2020 and grid costs could reach Eur 50 billion by 2030 without nuclear as government proposed.

Nuclear wastes

France reprocesses all of its spent fuel and uses part of the resulting fuel on other reactors; in addition, it has two underground repositories and research laboratories currently studying even more effective waste storage methods.

Among other sites, Auxon and Pars-lès-Chavanges in the State of Aube are currently conducting studies for a low-level waste repository possibly expected to start activity in 2019 (replacing those that have reached saturation). Such sites are part of the **40** applicant communities wishing to host the waste repositories.

Nuclear power plants in France do not operate on the same basis as in the rest of the world, because they are characteristically large power suppliers required to follow load, which makes high-performance maintenance a difficult task. In addition, some problems associated with workforce strikes as well as refueling outage difficulties generated losses in excess of 1 billion euros to EdF.

Governmental plans are to decommission Chooz A (310MW, PWR) plant by 2016, which supplied power for Belgium and France itself from 1967 to 1995. Dismantling, clearing and demolishing nuclear buildings took place prior to 2008. Today, 12 experimental and power reactors are being decommissioned. The process has been has been developed and studied by EdF- CIDEN and is to be applied to the entire French nuclear fleet upon the end of the plants' useful life.

French Government announced a € 1 billion investment plan in nuclear energy research and in the development and construction of a fourth-generation reactor to be produced by the French Areva and Japanese Mitsubishi and believe there is no alternative to nuclear energy today and that abandoning new nuclear reactors make no sense.

Energy exports from France to Germany have grown in 2011 more than 7 times in relation to 2010, up from 0.6 TWh to 4.4 TWh until October. The French Minister of Industry, Frances Eric Besson, declared that even with the Fukushima accident, nuclear energy remains a strategic advantage of his country.

Tests have shown a good safety level for French nuclear power plants, as reported to the regulatory body. The safety margins for such extreme events as earthquakes, floods, and simultaneous losses of coolant and power have been checked but revealed no major concerns; still, the operator EdF submitted a supplemental improvement plan.

The ten years' lifetime extension was authorized for the FESSENHEIM-1 plant which has been operational since 1978 was given in July 2011. This is the oldest French reactor in operation. The same occurs for FESSENHEIM-2 in May 2013.

The French government February 8 promulgated a new ministerial order governing major nuclear installations, a complete regulatory text that takes initial lessons from the Fukushima I accident into account.

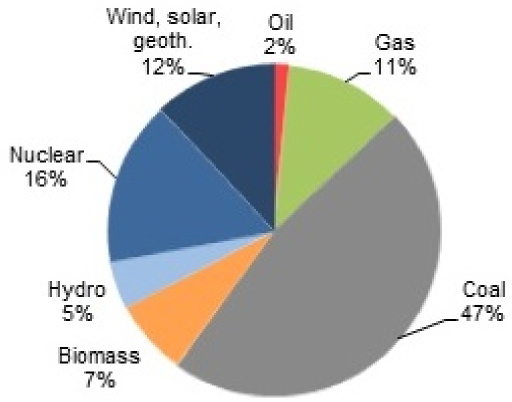
The AREVA issued a statement saying it intends to implement "a series of initiatives" aimed at reducing operating costs with up to EUR 1 billion in annual savings targeted by 2015. Areva is convinced that the outlook for nuclear development remains strong in the coming years, even if expansion of the global installed base of nuclear reactors is postponed compared with forecasts before Fukushima-Daiichi. Nuclear power remains a strategic advantage for its country.

Germany

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Germany	9	12,068	0	0	94.098	16,10

Germany has a total installed capacity of 161,570 WW, with a nuclear generating capacity of 12,068 MW from 9 authorized for operation plants (there are 17 operable plants, capacity of 21,366 MW but eight (Kruemmel, Brunsbuettel, Biblis A and B, Isar 1, Neckarwestheim 1 and Phillipsburg 1) have been shut down for political and legal reasons in German). Out of the remaining nine plants, six are among the 10 largest nuclear electricity generators in 2010. Nuclear plants produced 94.098 TWh in 2012, accounting for 16.10% of the country's electricity generation.

Germany electric power generation 2012



The cost would be high to replace the electric power generated from German operating nuclear plants with renewable energy, necessitating governmental subsidies from Europe's biggest economy. The country's electricity mix is a diversified one, with coal representing approximately 50%, gas 12%, wind 6% and other sources fill up the picture, besides the nuclear input, which is greater than 25%. Germany used to export more energy than it imported, but this picture has changed after the 8 reactors were shut down. In addition, German is one of the world's largest importers of primary energy.
It is also unclear how the country will fulfill its commitments to reduce national CO_2 emissions if it turned off all its reactors. The Germans heavily subsidized solar energy and also made a big bet on wind power and in both cases and in both cases counting on the support of imported electricity from nuclear sources in France, Czech Republic and Russia (if there are the lack of sun or wind). Currently they are planning to build a long transmission line from Sweden to import base load electricity produced by nuclear reactors from that country. Since domestic consumption (6,300 kWh/year per capita - approximately 3 times the Brazilian consumption) has not decreased, it became to be a matter hard to solve. It is also unfair to consider nuclear free, when in practice, there are outsourcing of nuclear plants.

In 2010, following extensive discussions, Congress approved a proposal allowing reactors to operate for 8 or 12 more years, depending on the plant's age, instead of the planned end of useful life – scheduled for 2022 – of the existing plants. With such proposal, some plants would operate for an additional 50 years.

After the Fukushima accident, once again Germany's government changed mind to overturn the 2010 position that favored operating life extension and all nuclear power plants were shut down for 3 months for safety tests. The older 8 plants will not be put back into operation. The others will be closed according to the schedule on the spreadsheet.

Accordingly, 10% of the country's electricity mix were prevented from being generated, and billion dollars' worth of investment was lost.

Operators which had their plants untimely closed by the German government in March 2011 (8,336 MWe of generation capacity) starkly protest the loss of profit and their inability to meet their market.

According to E. ON (Vice-Chairman Ralf Gueldner) the total cost of such decision will come to 33 billion euros, not to mention the costs of new transmission lines required by substitute generating systems and the costs of any possible power rationing programs which will certainly impair the country's industry. The ensuing increase in carbon emissions (estimated, as a minimum, at 70 million metric tonnes) will also bring conflicts with neighboring countries in the EU. Importing fossil and/or even nuclear energy will be inevitable, which undermines such policy's credibility.

Nuclear Reactors in Germany

Plant	Type	MWe (net)	Commercial operation	Operator	Provisionally scheduled shut-down 2001	2010 agreed shut-down	March 2011shutdown & May closure plan
Biblis-A	PWR	1167	fev/75	RWE	2008	2016	yes
Neckarwestheim-1	PWR	785	dez/76	EnBW	2009	2017	yes
Brunsbüttel	BWR	771	fev/77	Vattenfall	2009	2018	yes
Biblis-B	PWR	1240	jan/77	RWE	2011	2018	yes
Isar-1	BWR	878	mar/79	E.ON	2011	2019	yes
Unterweser	PWR	1345	set/79	E.ON	2012	2020	yes
Phillipsburg-1	BWR	890	mar/80	EnBW	2012	2026	yes
Kruemmel	BWR	1260	mar/84	Vattenfall	2016	2030	yes
Total shut down (8)		8336					
Grafenrheinfeld	PWR	1275	jun/82	E.ON	2014	2028	2015
Gundremmingen-B	BWR	1284	abr/84	RWE	2016	2030	2017
Gundremmingen-C	BWR	1288	jan/85	RWE	2016	2030	2021
Grohnde	PWR	1360	fev/85	E.ON	2017	2031	2021
Phillipsburg-2	PWR	1392	abr/85	EnBW	2018	2032	2019
Brokdorf	PWR	1370	dez/86	E.ON	2019	2033	2021
Isar-2	PWR	1400	abr/88	E.ON	2020	2034	2022
Emsland	PWR	1329	jun/88	RWE	2021	2035	2022
Neckarwestheim-2	PWR	1305	abr/89	EnBW	2022	2036	2022
Total operating (9)	12,003						
Total (17)	20,339 MWe						

The opinion expressed by E. ON is shared by the French Minister of Industry, Eric Besson, who believes Germany will grow heavily dependent on energy imports and will be a more polluting country, noting that German consumers who today already pay twice the amount charged by electricity bills in France, will be imposed an even heavier burden on their shoulders.
Companies' executive officers are planning to sue the government over what they view as confiscation of their revenues, inasmuch the competent regulator declared the plants safe and the electricity from the reactors now closed had already been sold.

After the shutdown of the old plants, the cost of electric power in Germany has already grown 12% and carbon emissions more than 10%. According to estimates by Germany's Ministry for the Environment and Conservation itself, even if the percentage of renewable energy sources doubled, it would still be necessary to invest 122 billion euros in the sector over the forthcoming 10 years, not to mention the investment in transmission lines, gas plants to back up renewable generation, and several subsidies for attracting investors, etc. According to Germany's Institute for Economic Research, costs may come to 200 billion Euros. In 2012 Germany had paid the Europe's highest prices for power.

In addition, a loss is expected of 11,000 direct jobs in the German nuclear industry, as reported by E. ON, and a strong cut in dividends.

Nuclear Power Plant Isar-2 , second biggest nuclear generator in 2010 – closed in 2011

Policy decisions in Germany, while important, are driven by national political forces - the real harm to people or the environment caused by the nuclear source has been extremely low, especially compared with the records of other energy sources currently in widespread use.

The Voerde Aluminium, the third largest aluminum producer in Germany, announced its bankruptcy on May 8, 2012 due to the reduction in aluminum prices combined with rising production costs. This was "an indicator of the gradual process of de-industrialization," said Ulrich Grillo, president of Germany's trade body for the metal industry, Wirtschaftsvereinigung Metalle (WVM). "Production of metals, especially aluminum, is at risk in Germany due to high electricity prices that are more competitive internationally," said Grillo.

German consumers that use more than 20 GWh per year pay 11.95 cents per kWh, compared with 6.9 cents in France, according to data from ENERGY.EU- November 2011. Among the 27 EU countries', only Cyprus, Italy, Malta and Slovakia have higher prices for heavy users of electricity. WVM asked the German government to urgently implement measures to protect energy-intensive industry from electricity costs and to encourage businesses to reduce metal emissions of carbon dioxide from their production processes. The industry should not suffer, Grillo said, because of "increasing price of electricity, clearly resulting system of state support for renewable energy, especially photovoltaic."

Subsidies have encouraged energy companies and homeowners to add about 25 gigawatts of solar capacity, especially in the last five years. This produced 2.4% of power generation in Germany in the 12 months through February 2012, according to statistics from the International Energy Agency (IEA), while the remaining 12 Gwe of nuclear capacity represented 15.3%. By far, the majority of German energy comes from fossil fuels, about 71%. The IEA data also shows that the export of German energy fell 0.9% in the year to February 2012, and imports rose 7.7%. Immediately after the accident of Fukushima, in in March 2011, Germans leaders Ruled the closing of the eight reactors in the country that began operating until 1980. The industry responded by calling fossil fuels in substitution. "As renewable energy sources do not provide power continuous ... we should use gas and coal for work", said Utz Tillmann, spokesman of an organ of intensive industry energy and director-executive Council European Chemical Industry.

In June 2012 a survey has shown that 77 percent of Germans are more concerned with keeping electricity affordable than phasing out nuclear energy. The survey was carried out by polling group TNS Emnid on behalf of the Initiative for a New Social Market Economy, which is funded primarily by employers in the metal industry.

In the meantime, contradicting this so-called safety policy, Germany continues to keep a very significant quantity of nuclear weapons in its territory, mostly operated by NATO.

Nuclear wastes

With respect to the nuclear wastes management policy, Germany has 2 final storage facilities for low- and intermediate-level radioactive wastes: the one at Morsleben, built by the former communist government of the late GDR, and the Konrad facility licensed in 2002 and finally released in 2007.

The German federal government and the country's 24 federal states have agreed on the framework for drafting a site selection law for a high-level nuclear waste and spent fuel repository, German Environment Minister Peter Altmaier said in a statement April 9. Altmaier said the government hopes a site selection law can be passed before the German parliament adjourns for its summer recess in July. The federal government and the states also agreed that new transports of spent nuclear fuel can be sent to the Gorleben salt mine. Gorleben is being used as an interim storage site, but that there is opposition to its use.

Hungary

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2011 (TWH)	% of total energy generated in 2011
Hungria	4	2000	0	0	14,763	45,90

Hungary's 4 nuclear power plants (Paks 1 to 4 – VVER-PWR 500 MW) whose commercial operation started between 1982 and 1987 have produced 14.763 TWh, that is, around 45,90% of the country's electricity generation in 2012. Such electric power is the cheapest one generated in Hungary and, according the governmental sources approximately 73% of the population supports nuclear power.
In 2004 the plants were given authorization to operate for more 20 years, and in 2009 the country's parliament authorized the government to start expanding existing site's capacity through

the construction of an additional one or two nuclear units on the same location of the Paks power station. Studies for definition of the type and size of the reactor are still under way.

June 2011 – State-owned company MVM has plans to expand the capacity of its Paks nuclear plants and accordingly increase its influence on the energy markets of its vicinity (Balcans-Croatia, Serbia and Bosnia and in Rumania). The decision to expand Paks nuclear power station is to be published in September, with the preparatory work being under way as authorized by the Parliament.
Test results on the Hungarian plant have been satisfactory according to the governmental regulatory body, requiring no additional safety measures.

NPP Paks – Hungary

Pal Kovacs – Hungary's Minister of National Development declared that for all energy planning scenarios studied by the country, nuclear supply is indispensable. The 2030- 2050 energy plan recommends a 20 years' lifetime extension for the 4 units of Paks nuclear station, whose useful lives would be over in the period from 2032 to 2037. In addition, the country intends to expand by 2,000 MW the station's capacity (2 new 1000 MW units, each) until 2025. The cost is estimated at 10 billion dollars.
16/12/2011 - Prime Minister Viktor Orban said the goal is to have nuclear power provide 60 percent of the country's electricity needs, compared with around 40 percent now. The Czech Republic's government plans to at least double that output over the next 50 years

Hungary plans to open a tender for two additional units at its four-reactor Paks plant in early 2013, Pal Kovacs said. The earliest possible start-up dates for Paks-5 and Paks -6 are 2022 and 2025, respectively, Kovacs said. Kovacs said five designs are being considered for the two new units — Areva's EPR, the Areva-Mitsubishi joint venture Atmea's Atmea1, Atomstroyexport's VVER-1200, South Korea's APR 1400, and Westinghouse's AP1000.

In December 2012 Hungary's Paks 1 nuclear power plant (VVER 500MW) has been granted a permit to operate for another 20 years after its original license expires at the end of 2012.

Italy

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2011 (TWH)	% of total energy generated in 2011
Italy	0	0	0	0	0	0

In 2010, Italy's electric power was primarily generated from fossil – 64.8% and renewable fuel 22.2%, and from imports - 13%.

Italy has no nuclear power plants in operation. The phase-out of its 4 plants - Caorso; Enrico Fermi (Trino Vercellese); Garigliano and Latina – was completed in July 1990 (2 by popular decision and 2 for completion of useful lifetime). Italy is the only country in the G8 – group of the world's richest countries plus Russia – that does not operate nuclear power plants. Notwithstanding, around 10% of the electricity consumed in its territory are from nuclear power, imported mainly from France, where 77% are generated by nuclear plants.

Enrico Fermi (Trino Vercellese) is under decommissioning.

In 2008, the country decided to resume its nuclear program which was stopped in the 1980's, ridding itself of its dependence on oil through a fast development of nuclear energy.

According to the Minister of Economy and Development, Claudio Scajola, the cost for the Italian economy from the phase-out of nuclear power was 50 billion dollars, and all the legal framework legal for resumption of nuclear energy was being adopted under the new national energy plan. On July 9, 2009 the Senate approved a legislative package giving green light to bring nuclear energy back to Italy, it being reported that in up to six (6) months potential sites would be selected for the setting up of new plants.

The reactor model to be adopted should be one already licensed in Europe, which would save licensing time, inasmuch as the plan was to build 8 to 10 reactors by 2030, reaching a share of 25 % Italy's electricity generation.

At present, the cost of electric power in Italy (a 60% dependence on gas imports) is 30% higher than the European average, and 60 % higher than France's.

Since November 2008, Italy - through its power company ENEL which holds 66% of Slovakia's SE-SLOVENSKE ELEKTRARNE - is building Mochovce 3 and 4 (VVER-440 MW each) plants, which are expected to be in commercial operation by 2012 and 2013, respectively. The planned investment is 2.77 billion euros. When in operation, the output from these plants will represent 22% of the total electricity consumed in Slovakia.

Another Italian nuclear business was the acquisition, through ENEL, of 12.5% of the shares in French plant Flamanville-3 (owned by EdF) which is under construction in Normandy. These actions are aimed not only at the investment, but also the formation of skilled personnel, inasmuch as it is more than 20 years since Italy closed its nuclear industrial framework.

In June 2011, the majority of Italian voters passed a referendum to cancel plans for reinstatement of nuclear energy in Italy. Those voting against nuclear were 94% of the voting population (57% of the eligible population), which corresponds to 53.58 %. The manner in which the voting questionnaire was laid out was not specifically against nuclear energy, but an overall disapproval of the then government (Silvio Berlusconi) and its plans of action. Italy is a country prone to large magnitude earthquakes and this much contributed to the population's fear, strongly exploited by environmentalists. With that, the country will keep on obtaining nuclear generated electricity through power company ENEL in Slovakia, and imports from French EDF.

In addition, AREVA and ANSALDO NUCLEARE had signed an agreement whereby ANSALDO would participate in the licensing process for construction of AREVA's new reactor (EPR) in Italy, but with the Italian ban of nuclear power plants the agreement then prevailed for any place in the world through the joint venture set up on 10/11/2011. ANSALDO is also planning to fabricate super modules for Westinghouse's AP1000 destined for the British market.

Netherlands

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Netherlands	1	482	0	0	3,71	4,4

The Netherlands has only one nuclear plant in operation (Borssele PWR 482 MW). In 2012, it produced 3.71 TWh, or approximately 4.4 % of the country's electricity. Such plant had its useful lifetime extended by 20 years in 2006, and is planned to continue in operation until 2033.

NPP Borssele – Netherlands (Image: EPZ)

The country also has a research reactor in the town of Petten, the HFR - High-Flux Reactor which produces 60% of required medical radionuclides in Europe (30% of world demand). The country imports more than 20% of its electricity (mostly from Germany). The energy per capita consumption is 6,500 kWh/ year.

2009, Delta submitted to the cognizant governmental body the application to build the new 2500MW nuclear power plant. Company ERH - Energy Resources Holding acquired by German RWE, which owns the other half of Borssele, also requested authorization to build another plant in the Netherlands.

The Dutch government has announced the forthcoming start of the licensing process for Borssele nuclear power station's second unit. Neither the design nor the vendor has been defined, but the plant's capacity is reported to range from 1000 to 1600 MW. It is expected to be in operation by 2020, in time to realize the greenhouse gas reduction goal. MOX will be the fuel and the project's cost is estimated at 5 to 7 billion dollars as informed by company Energy Resources Holding in September 2010. In November 2010, Dutch company Delta (holding 50% of the existing plant) and EdF signed a cooperation agreement for the possible construction of a new nuclear power plant in the Netherlands, on the Zeeland Coast site.

The Netherlands' only nuclear plant had gone through the EU stress test after Fukushima accident. In June 2011, the use of MOX fuel was authorized. In January 2012, due to financial crisis in Europe and also the uncertainties on the carbon market the plant was postponed.
According to the government, the Netherlands will continue its nuclear program contemplating the construction of the new nuclear power plant.

In addition, an agreement between the Netherlands and France covers the recycling in France of part of Dutch plants' spent fuel. After reprocessing, the material is shipped back to the Netherlands (COVRA Storage Facility near Borssele) following strict safety standards laid down by the IAEA.

In January 2012 the Dutch government announced that a new research reactor (called Pallas) will be built in the region of the Petten reactor to replace existing (High-Flux Reactor-HFR) operating since 1961 and is reaching the end of its economic life useful. It is anticipated the entry into operation of the new reactor in 2022.

Norway

Norway is the sixth largest producer of hydropower. Although Norway has no nuclear electricity generation program, the committee set up by the Norwegian government to study sustainable energy options recommended in its report that nuclear energy's contribution to a sustainable energy future should be recognized.

The country also makes nuclear research in its Energy Technology Center where it was tested a nuclear fuel which will be used in Brazilian nuclear submarine (it was an essay that required sophisticated scientific qualification flawless team involved and had the participation of a group of Brazilian Navy scientists from Center Aramar).

Poland

The country has a population of 38 million and an electricity mix currently mostly based on coal (94%).

To reduce its CO2 emissions, Poland is now pondering the possibility of building its first nuclear power plant by 2024, a move to starting changing its electricity mix.

The Polish government commissioned its major power company (PGE - Polska Grupa Energetyczna SA) to conduct the country's first two nuclear power plant projects which are planned to have a 3000MW capacity, with two or three reactors each. It is expected that the first plant will come on stream by 2024.

The Zarnowiec site could be used due to the availability of infrastructures already in place. In 1986, Russia was building 4 WWER reactors, 440MW, for Poland in Zarnowiec, north of Gdansk, but the project was dropped in 1989, following a referendum strongly influenced by the Chernobyl accident The reactors that had already been delivered were sold to Finland (Loviisa) and Hungary (Paks). On the basis of studies already conducted, the existing site (photo) could use the available infrastructures and host the future plant.
In April 2010, a memorandum of understanding was signed between Westinghouse and Poland's Polska Grupa Energetyczna (PGE) on a joint feasibility study for the construction of a third-generation reactor (Generation III+) in Poland (AP1000).

In July 2011, Poland's Parliament passed the last law necessary for the start of construction of the country's first Nuclear power station. As soon as President Bronislaw Komorowski signs the law, gigantic state-owned Polska Grupa Energetyczna - PGE will be allowed to commence construction work on up to 2 plants, with a capacity for up to 6 GWe, which are expected to be ready by 2020.

Polish state-owned utility PGE said December 9, 2011 it had decided not to participate in the Visaginas nuclear plant project in Lithuania nor contract for electricity from Russia's proposed Baltic nuclear power plant in Kaliningrad.

Site in Zarnowiec – Poland

The selected technology should belong to one of the competitors - AREVA, GE Hitachi and Westinghouse - invited to submit bids until January 2012.

According to Prime Minister Tusk, the government is convinced that nuclear energy constitutes a good alternative to meet Poland's electricity needs, as well as a great business opportunity, including the possibility energy sales to Germany.

In September 2012 The polish power companies Tauron and Enea and copper miner KGHM signed a letter of intent September 5 with PGE, the country's largest utility, to participate in PGE's project to build 6 GW of nuclear capacity by 2030, the companies said in a joint statement. The Polish government tasked PGE to lead a consortium to build two nuclear power plants in separate locations by 2030 but there was concern about PGE's ability to finance the project alone.In September 2013 PGE said it would maintain 70% equity in PGE EJ, with 10% each being held by ENEA, Tauron and KGHM, and all four parties initialled an agreement accordingly.

Romania

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Romania	2	1414	2	1440	10,563	19,4

Romania has 2 nuclear power plants (Cernavoda 1 and 2- PHWR 650 MW) in commercial operation with 19.5% of electricity generation from nuclear reactors in 2010. The two plants are operated by SNN - Societatea Nationala Nuclearelectrica. Units 3 and 4 (720 MWe Candu, each) are going through financing problems, being scheduled to start commercial operation by 2016.
An agreement between six investor companies - ENEL (9.15%), CEZ (9.15%), GDF Suez (9.15%), RWE Power (9.15%), Iberdrola (6.2%), and ArcelorMittal Galati (6.2%) - and Romania's SNN- Societatea Nationala Nuclearelectrica (51%) was signed on November 20, 2008 for completion of the reactors at Cernavoda-3 and -4 (PHWR Candu -750 MW each), on the same site of the operating plants 1 and 2.

NPP Cernavoda – Romania – The units 1 and 2, on right side are in operation

In 2011, companies European Iberdrola (6.2%), RWE Power (9.15%), GDF Suez (9.15%), CEZ (9.15%), gave up participating in the project due to the market and economic uncertainties, and SNN- Societatea Nationala Nuclearelectrica started to hold 84.65% of the investment. SNN said that China Nuclear Power Engineering Co. (CNPEC, a subsidiary of CGNPC) was interested in investing in the two new Cernavoda units, and later a South Korean consortium also expressed interest. Bids were open until mid-November 2011 to partner with SNN, Enel and ArcelorMittal in Energonuclear, with the new investor taking about 45% of the project. Apparently no bids were received.

In October 2012 the government asked the four major utilities - GdF Suez, Iberdrola, RWE and CEZ - which had withdrawn from EnergoNuclear SA to reconsider involvement in the Cernavoda 3-4 project.

The country produces its own fuel since the 1980's at the Pitesti Nuclear Fuel Plant (FCN).

Due to financing difficulties, Romania's government had not provided the promised funds, and SNN was unable to cover the project's costs.
The big problem faced by the country is the lack of resources to complete its constructions. Its reactors are the CANDU type and the design is large-earthquake resistant. The site is above the area theoretically hit by the greatest flood of the Danube River (per a study encompassing 10,000 years), and also much above the level of the Black Sea, among other safety-related aspects. According to the country's authorities, it would be very unlikely that something similar to Fukushima would happen.

Russia

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Russia	33	25242	11	10046	165.594	17.80

Russia has 33 plants (25242 MW) in operation (15 of them equipped with the RBMK reactor or LWGR – the same model used in Ukraine's Chernobyl plant), 11 plants under construction (1RBMK, 1 FBR and 9 VVER) and 20 planned plants with a net capacity of 21,400 MW which have chosen location and date of planned operation. There are still 24 more units (24.180MW) planned for the future without construction's information.

The plants in operation in 2012 produced more than 165 TWh of energy or 17.80% of the country's energy.

In July 2012, the director general of Rosatom – Russia's state-run nuclear company said that the Russian government has plans for the construction of new nuclear capacity up to 2020, which will corresponds to around 30 GW. It will expect that nuclear energy represents 25% or 30 % of total in the country at this time. The country's per capita consumption is nearly 3 times greater than Brazil's, for a population of around 142 million inhabitants.

Generally, Russian reactors are licensed for 30 years from first power. Nowadays plans were announced for lifetime extensions of twelve first-generation reactors (Leningrad 1&2, Kursk 1&2, Kola 1&2, Bilibino 1-4, Novovoronezh 3&4) totaling 5.7 GWe, and the extension period envisaged is now 15 to 25 years, necessitating major investment in refurbishing them. Three plants with the RBMK reactor (Leningrad 1, 2 and 3) had their lifetimes extended by 15 years following changes and improvements to the original design.

NPP Kursk (5 reactors - type LWGR
(1 under construction photo: Atomenergoproekt

Control Room of Reactor Leningrad
(RBMK or LGWR)

The second unit of the Volgodonsk nuclear power station (also known as Rostov) came into commercial operation in late 2010, there exist 2 more under construction on the same site, expected to be ready by 2016. Under a resolution enacted in November 2011 the government will build 2 more reactors (Monakovo plant, VVER-TOI) in the region of Nizhniy Novgorod, with a 1,150 MW capacity. Such plant would be already the new generation of Russian water moderated reactors.

The efficiency of nuclear electricity generation has grown strongly over the past decade (the availability rising from 56% to 76%), and the electricity mix is trying to follow the growth of consumption, which has been keeping rather significant levels.

The focus on nuclear electricity generation by Russia's energy policy is aimed at enhancing natural gas exports to Europe – a more profitable business than its use for domestic electricity generation – and the replacement of generating fleet, which is nearing the end of its useful life.
Russia has been signing a series of commercial and cooperation agreements with several countries for construction of new reactors, nuclear fuel development and exploitation and research in the nuclear area in general, setting up an extensive network of influence around the

world. According to Russian government leaders, this should allow the country to be a trading partner in 30% of new business transactions in the nuclear area, and to possibly hold 38% of the nuclear reactors and services market by 2030.

The economic-financial crisis at the end of 2008 strongly affected the Russian economy. Industrial production fell more than 7% and, as a consequence, energy consumption was pushed down. Nevertheless, government leaders explain that nuclear plans will just be “put off” in time, which will allow new plants to be connected later on, by 2020. Replacing older reactors with new ones remains as part of the goal of a 25% reduction in carbon emissions up to 2020.

Rosatom, Russian state-run nuclear company began in February 2012 the construction of the Baltic Nuclear power plant (two reactors VVER 1200MW) in the Kaliningrad district, on the border with Lithuania (just 10 Km far away). Such project is viewed as a competitor with the Visaginas nuclear power plant which would replace the electric power from Ignalina (Lithuanian RBMK reactor, closed in 2009). In November 2011, Russia’s regulatory body – Rosetekhnadzor awarded the license for the nuclear plant.

Volgodonsky NPP (type PWR) in Russia - Photo: Energoatom

Novovoronezh - Russia
3 units in operation, 2 under construction,
2 planned e 2 closed

In view of the findings of power shortage studies on the Baltic region foreseeing a capacity deficit of 2,000 MW, Russia has guaranteed to private investors the large potential of that plant, whose units are planned to operate in 2016 and 2018 respectively. The project also includes the transmission line that will distribute electric power to neighbors (BRELL – Belarus, Russia, Estonia, Latvia and Lithuania).
Rosatom said it is building or contract to more 28 reactors worldwide and in the next 20 years plans to buy equipment and services for nuclear facilities worth more than $300 billion (238 billion euro).

Iran's reactor built by Russia came into commercial operation in 2013 and a new business agreement with Bangladesh should be signed by the end of the year.

With respect to Fukushima, although not a member of the Bloc, the country will do the same safety tests as other EU Nations. A program of inspections is underway on Russian power stations with respect to the possible risks faced by the operator in the event of failure of emergency water and power supply for coolant systems. Following these, in mid June 2011 Rosenergoatom announced a RUR 15 billion ($530 million) safety upgrade program for additional power and water supply back-up. Rosenergoatom spent RUR 2.6 billion on 66 mobile diesel generator sets, 35 mobile pumping units and 80 other pumps, besides I&C equipments.Since the Fukushima event, Russia has kept the construction of Leningrad power plant 2 (second phase), continues with construction in China (2 units), India (2 units) and signed construction contracts for 12 new plants (4 in Turkey, 2 in Belarus, 2 in Bangladesh, 2 in Vietnam and more 2 in India), all of them already meeting the requirements arising from Fukushima.

Nuclear wastes

Russia reprocesses spent nuclear fuel at Mayak reprocessing plant on the Ural Mountains. Another Russian novelty is the floating nuclear power plant in Pevek, located in the arctic region of Chukotka, where the population favored the project after dismissing threats from the facility to the region's surrounds. A proposal was approved at a public debate called by the authorities of the Chaunski municipal district, where Pevek is located, with the attendance of workers, assemblypersons and activists, as informed by official agency "RIA Newti". The local authorities had set up an exhibition on the project in the municipal library to inform the region's residents on the environmental impact of the plant.

In the decommissioning area, Russia (Rosatom and Tvel) completed the first decommissioning of a civil facility, and the experience acquired will be used by the nuclear industry in the future. The work was carried out in a uranium pellet plant that was returned to greenfield status. The project's cost was equivalent to 21 million dollars and, because of the complex operations involved (dismantling equipment items, demolishing structures, removing contaminated soil, etc.) the work required nearly 4 years.

Slovakia

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Slovakia	4	1.896	2	880	14,411	53,79

Slovakia's 4 nuclear reactors in commercial operation produced 14.411 TWh of electricity, in 2012, which accounted for 53.79% of the country's energy generation. The two units under construction are Mochovce-3 and -4 (VVER 440MW each) and were expected to come into operation in 2014 and 2015 respectively, but there are some delay in completion. Plans also contemplate the construction of 2 other reactors in the period from 2020 to 2025.

As a preparatory step towards accession to the European Union, in 2004 the country agreed to the decommissioning of its two oldest reactors (Bohunice V1 unit 1 and 2), which took place in 2006 and 2008.
Seeing that the *per capita* energy consumption is 4,550 KWh a year and as more than 50% of the generating capacity comes from nuclear sources, fuel supply stability and security are paramount for the population's quality of life. Russian company TVEL has been engaged the supply all nuclear fuel requirements.

NPP Mochovce (www.seas.sk/en)

In 2008, Slovakia decided that its high-level radwastes would be reprocessed, and studies are under way on the siting of a repository for low- and intermediate-level radioactive waste.

Slovakia is part of the NPT since 1993 and also signed the additional protocol in 1999. The country is also a member of the NSG - Nuclear Suppliers Group. Construction work is continuing on the Mochovce-3 and -4 plants. As is the case across Europe, Slovak plants will go through the stress tests called for by the EU.

Slovenia

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Slovenia	1	727	0	0	5,244	35,95

Slovenia has a population of 2 million. Neighbouring Croatia has 4.5 million people. Together they have 1 nuclear reactor - KRSKO (PWR, 727 MW) in operation since 1981. In 2012, KRSKO produced 5.244 TWh of electricity, supplying 35.95 % of the Slovenia's electric grid.

The reactor is shared (50%) with Croatia. For Croatia this energy was about 15% of total.

KRSKO reactor was designed for 40 years operation, but a 20 years life extension is expected.

KRSKO reactor

Slovenia has a 250 kW Triga research reactor operating since 1966 at the Josef Stefan Institute.

Nuclear wastes

In January 2010, Slovenia - through its Agency for Radwaste Management - ARAO (*Agencija za radioaktivne odpadke*, in Czech) selected a site (Vrbina) near the nuclear plant, for the construction of a Low- and Intermediate-Level Waste repository, as authorized by governmental decree in December 2009.

The repository, consisting of 2 silos, will have a capacity for 9,400 cubic meters of low- and intermediate-level radioactive material, which corresponds to half of all wastes generated during the operation and future decommissioning of the nuclear plant. The possibility also exists for the

facility to be expanded to store nuclear wastes from other sources. The system's capacity could be increased to cope with the possible growth of the country's nuclear program. Slovenia is to maintain its nuclear power program despite the Fukushima accident, as declared by the Economy Minister Darja Radic in June 2011.
In all energy scenarios for the country up to 2030, the nuclear option is emphasized. The government also announced the likely construction a second reactor at Krsko within the national energy program which is pending final approval no Parliament.

Spain

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Spain	**7**	**7.514**	**0**	**0**	**58,70**	**20,50**

Spain has 7 nuclear reactors (6 PWR and 1 BWR) in operation, with a total 7, 514 MW installed capacity. In 2012, 58.70 TWh of electricity were produced, corresponding to 20,50 % of the country's total electricity generation but the Nuclear's installed capacity is only 7.32% of the total, with a load factor among the highest.

In Spain, nuclear power plants do not have a limited period of operation. From the day a plant starts operation it is granted permits that are renewed every 10 years without a legal limit.

Two reactors have been shut down:

- **Vandellos 1** in 1990 - on which the decommissioning work is in an advanced stage
- **Zorita-Jose Cabrera** in 2006, whose decommissioning has been awarded to Westinghouse.
- Spain's oldest reactor **Garona** (466 MW BWR) - In October 2012 the Spanish government has proposed two new taxes on nuclear energy and in December 2012 the operator Nuclenor, owner of plant has been closed for no longer meet economic requirements, after the enactment of new government taxes imposed on the operator.

NPP Vandellos 2 – Spain

In May 2013 , the Spanish Nuclear Safety Council (CSN) has approved a request from Nuclenor (joint venture Endesa-Iberdrola), the operator of the **Garoña** nuclear power plant, to delay the deadline for filing a license renewal demand that would have extended the operations of Garoña until 2019. With this new delay, Nuclenor will have time to submit a renewal license.

For political reasons, Spain is planning to have nuclear power plants closed at the end of reactor lifetime, without their installed capacity being replaced through other nuclear plants. Notwithstanding, in December 2009 a new law was approved which allows plants to operate beyond their original 40 years' useful life, if the country's Nuclear Safety Council declares them to be safe. An example of this was the authorization, in June 2010, to extend the lifetimes of Almaraz-Trillo plants and Vandellos 2, by an additional 10 years.

Nuclear wastes

At the end of December 2009, the Spanish government opened up a register of applicant communities wishing to host the Centralized Storage Facility for Spain's spent fuel, planned to have a capacity for 6,700 tonnes of spent fuel and vitrified waste from fuel reprocessing. The repository's initial capacity should meet the country's requirements for 60 years.

The country has a low- and intermediate-level repository in operation since 1980's - "El Cabril", designed by Westinghouse Electric Spain (WES). The decision on a storage facility for high-level waste is still on hold.

30/Dezembro 2011 - The Spanish government has picked a site (at the city of Villar de Canas in Cuenca Province) to store the country's spent nuclear fuel and high-level radioactive waste, marking the end of a nearly two-year selection process that involved 14 municipalities that had volunteered to host such a facility. The ministry said construction of the centralized storage facility, known by its Spanish acronym ATC (*Almacén temporal centralizado de España)*, is estimated to cost Eur700 million (about $908 million) and bring an average of 300 jobs to the region.
The project involves building a dry storage facility for spent fuel and vitrified high-level waste and a technology center to support the site, it said. The ministry said additional site-specific environmental evaluations have to be performed and authorizations obtained before construction can begin.

The ATC is necessary because spent fuel pools at the country's nuclear reactors are filling up. According to a generic design of the facility — provided by state-owned nuclear waste management company Enresa and approved by the Nuclear Safety Council in 2006 — the ATC would hold an estimated 6,700 mt of spent fuel, 2,600 cubic meters of intermediate-level waste and 12 cubic meters of high-level waste.

In October 2012 the Spanish government has proposed two new taxes on nuclear energy as part of a draft law being presented to parliament.

The first nuclear energy tax is the production of radioactive waste resulting from nuclear power generation at 2.190 euro (EUR) (2.878 US dollars) per kilo of heavy metal produced.

The second tax is on radioactive waste storage and will replace current taxes imposed by autonomous regions. It will bring "coherence and consistency and unify the tax system of various autonomous regions", the ministry said. Spain's Minister for Industry, Miguel Sebastián, called for a review of the safety systems at all Spanish nuclear power plants, to draw on the lessons from Japanese event. Along the same line, he declared that additional assessments covering the seismic occurrence and flood risks have been ordered.
In August 2011, Spain's nuclear regulator (Consejo de Seguridad Nuclear-CSN) unanimously approved a 10-year lifetime extension for the 2 nuclear units of the Ascó nuclear power plant (up to 2021).

NPP Almaraz-Trillo

On September 15, the CSN informed that all 8 nuclear power plants had passed the stress tests proposed by the European Union and that plants' safety margins make them capable of resisting accidents beyond their design bases. Accordingly, María Teresa Dominguez, president of FORO NUCLEAR, declared that nuclear power must continue as part of Spain's electricity mix.

The new government elected in November 2011 has already stated that the Spanish electricity mix will be one that ensures the reduction of CO_2 emissions.

Sweden

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Sweden	10	9.281	0	0	61,473	38,11

Sweden has 10 nuclear reactors in operation that produced 61.473 TWh of electricity in 2012. There are 3 closed reactors, 1 for end-of-life (Agesta) and 2 (Barsebäck) for political reasons. The capacity increase of the country's existing reactors amounted to approximately 1150 MW, practically matching the capacity of Barsebäck 1-2 reactors (BWR-600MW) and 2 (BWR-615 MW), that were prematurely shut down in 2004 and 2005. With a population of about 9 million, this represents approximately one reactor per each million inhabitants.

Electricity production in Sweden is dominated by two generating sources - hydro with about 50% of the power grid's capacity, and nuclear with 45%.

NPP Oskarshamn 3 units (2.308 MW) – Sweden

The expansion of such production rates was limited by laws protecting rivers and prohibiting the construction of new reactors.

In June 2010, country's authorities officially abolished the legislation banning the construction of new reactors, and since January 2011 new reactors are allowed to be built to replace the oldest ones reaching end-of-lifetime or to increase the country's generating capacity and ensure energy supply security.

Vattenfall Company wants to buy land adjacent to the Ringhals nuclear power plant to build another power reactor, Mats Ladeborn, the director of the Swedish power company's nuclear power development unit, said in a June 3statement. Under Swedish law, new reactors may be built to replace units that will be permanently shut. Reactors may only be built at the sites of the three existing nuclear power plants operating in Sweden: Ringhals, Forsmark and Oskarshamn.

By 2025 at least four reactors will reach the end of life and will be closed resulting in the loss of more than 22 TWh of steady energy in the country. The Swedish government, through its Prime Minister, vowed the decision will be maintained to replace nuclear reactors coming to the end of their useful lives.

Sweden's nuclear power reactors					
Reactor	Operatorb	Type	MWe net	Commercial operation	closure (aprox.)
Oskarshamn 1	OKG	BWR	473	1972	2022?
Oskarshamn 2	OKG	BWR	638	1974	2034
Oskarshamn 3	OKG	BWR	1400	1985	2035
Ringhals 1	Vattenfall	BWR	859	1976	2026
Ringhals 2	Vattenfall	PWR	866	1975	2025
Ringhals 3	Vattenfall	PWR	1045	1981	2041
Ringhals 4	Vattenfall	PWR	950	1983	2043
Forsmark 1	Vattenfall	BWR	987	1980	2040
Forsmark 2	Vattenfall	BWR	1000	1981	2041
Forsmark 3	Vattenfall	BWR	1170	1985	2045
Total (10)	9388				

Nuclear wastes

With a nuclear generating fleet where all reactors have been operating for twenty to thirty-eight years, operation safety and waste storage processes are a constant concern. In June 2009, the Nuclear Fuel and Waste Management Company - SKB, an independent company run by the operators of nuclear power plants in Sweden, selected a site (Östhammar municipality) near the Formark plant to host the country's final storage facility for spent fuel.

Every year, more than 10,000 people visit the test caverns of Aspo Hard Rock laboratory, a model where the spent fuel from nuclear power stations can be stored. As general information policy, the population is encouraged to get to know the solutions proposed.

Östhammar – Sweden Selected site for construction of waste storage

The communities in the area competed with one another to host the facility, and more than 80% of the local residents favor the repository. The operation starting date of the final repository will possibly be in 2023 if the proposed schedule is met. According to the spokesperson of the nuclear Fuel and Waste Management Company (SKB), Inger Nordholm, the policy that has led to this position is one of complete transparency with the communities, stating what is meant to be done, why it should be done, and how a place for it will be found.

Switzerland

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Switzerland	5	3.352	0	0	24.445	35,9

Switzerland has 5 operating nuclear reactors (3,352 MW installed capacity distributed in PWR and BWR type reactors) which produced 24.445 TWh of electricity in 2012, accounting for 35,9% of the country's electric grid. With a population of 7.6 million, this represents approximately one reactor per each million and a half inhabitants.

Such plants were designed for 50 years' operation and their current operating licenses are due to expire between 2019 and 2034 when they will reach lifetime limits.

Swiss Power Reactors in Operation					
Reactor	Operator	Type	MWe net	start operation	closure (aprox.)
Beznau 1	NOK	PWR	365	1969	2019
Beznau 2	NOK	PWR	365	1971	2021
Gösgen	KKG/Alpiq	PWR	985	1979	2029
Mühleberg	BKW	BWR	372	1971	2022
Leibstadt	NOK/Alpiq	BWR	1165	1984	2034

Switzerland has been long looking for a suitable site to build a final repository for nuclear wastes. In the meantime, such wastes are transported to interim storage facilities in Sellafield (England) and La Hague (France), but should return to Switzerland as soon as the final repository is available. The operation starting date of the waste storage facility is scheduled for 2024.

Every year, the five Swiss reactors produce around 75 tons of spent fuel which, at the end of their planned lifespan, will total 3,000 to 4,300 tons (around 7,300 m3), depending on the operating conditions of each plant.

The company responsible for nuclear waste management in general also estimates that low- and intermediate-level radioactive and waste from medical activities will bring this to a total of 93,000 m3. The costs generated by decommissioning of plants, storage and transport, interim storage, and deep geological storage of such material, besides related research and development, are already charged to consumers on electricity bills.

Producers of medical wastes pay a fee to the government which is responsible for all such services. Considering the Fukushima event, although not a member of the Bloc, Switzerland will

do the same tests as other nations of the EU. The conclusions from the preliminary tests are that the nuclear plants have high safety levels.
Three construction applications for new nuclear plants were under review by Swiss federal authorities when the accident occurred and, as a consequence the processes were put on hold.

Proposed laws calling for a ban on nuclear energy are not overly rigid and provide for periodic assessments of the country's energy situation vis-à-vis world technology development as a means for energy policy changes.

Ukraine

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Ukraine	15	13.880	2	2.000	84,885	46,2

Ukraine has 15 reactors in operation with an installed capacity of 13,880 MW (13 VVER 1000MW and 2 VVER 400 MW) and 4 closed units (Chernobyl – 3 RBMK 925 MW and 1 RBMK 725 MW). Zaporozhe nuclear power station in west Ukraine is Europe's largest, with 6 VVER type reactors, 950 MW each. In 2012, Ukrainian nuclear power plants produced 84.885 TWh, representing 46.20 % of the country's electric power. With about 45 million people (2010 census) and the dimensions of the state of Minas Gerais, in Brazil, it has a reactor for every 3 million people and consumes almost double the energy per capita of Brazilians.

Ukraine's primary energy sources are coal, gas and uranium, but gas – as well as oil – is imported from Russia, which also supplies nuclear fuel. Such energy dependence has brought political problems for the country which would like to find substitutes for energy supplies.

In 2004 Ukraine completed, commissioned and put into commercial operation Unit 2 of Khmelnitski station (1000MW – VVER); in addition, Rovno's Unit 4 (1000MW – VVER) was commissioned and started operation.

NPP Khmelnitski

Russian company Atomstroyexport will complete the construction of units 3 and 4 of Khmelnitski power station (1000MW – VVER, each), as approved in October 2008. The construction had been suspended in 1990. Construction work on unit 3 is 75% complete and plant 4, 28%.

According to data from the World Nuclear Association – WNA there exist 22 planned reactors in Ukraine, with 9 being intended to replace older ones scheduled to be shut down by 2035, and thirteen are new plants to meet country's future consumption requirements.

In October 2012 The International Energy Agency – IEA released a review of Ukraine's energy policies, where they say Ukraine will need between three gigawatts (GW) and 5GW of new nuclear capacity, for which it has already drawn up a list of possible sites. A decision on new build is expected between 2015 and 2018 with investment costs likely to range from 12 billion US dollars (USD) (9.2 billion euro) to USD 20 billion, the report says. The report says nuclear energy is “a key pillar” of the country’s draft Update Energy Strategy, which details energy policy until 2030.

The country has done the same stress tests as EU nations, even though it is not a member of the Bloc.

Nuclear wastes

Ukraine does not reprocess its wastes and these are stored at the plants themselves.
Chernobyl’s 4 reactors are being decommissioned. Unit 4 which was destroyed in 1986 by a nuclear accident, with explosion and release of radioactivity, is encapsulated in a sarcophagus, and a new protective structure is being built on it.

After the fall of the Soviet Union, Ukraine negotiated the repatriation of nuclear warheads which were in its territory and their transformation into nuclear fuel, thereby ridding itself of the risk of any accident with atomic weapons and being enabled to sign the Nuclear Non-Proliferation Treaty - NPT.

Other European Countries

Baltic countries (Lithuania, Estonia, Byelorussia and Latvia)

Being too small to bear the construction costs of a nuclear plant, the Baltic countries wish to join into a consortium to build a plant. Together, they can also benefit from lines of credit which they are entitled to with the Nordic Investment Bank. The Project could also include Poland, but it had decided not participate.

Byelorussia

In March 2009, Byelorussia signed an agreement with Russia, through its Atomstroyexport, for the construction of the country’s first nuclear plant. An international competitive bidding process was launched for the supply of technology and construction services. In addition, on 10/11/2011 a construction contract was signed with Russian AtomStroyExport (ASE) for two plants in Byelorussia. This will be a turn-key project at an estimated cost of around 9 billion dollars, with the first plant to be commissioned in 2018. The Ostrovetsk site in the region of Grodno has been selected for the project (2 x VVER -1200 MWe AES-2006).

Simulation of 2 units AES-2006 (Image: AtomEnergoProekt)

In July 2012, Belarus signed a construction contract with Atomstroyexport of Russia for two reactor units as well as fuel supply, take-back of spent fuel, training and other services.
The Byelorussia Project will go through same tests as those applied to EU nations, although the country is not a member of the Bloc.

The reactors will be manufactured by AEM-Technologies, AEM's St. Petersburg-based heavy engineering subsidiary, at the Volgodonsk facility owned by Atommash. Atommash is part of the Energomash group and is a joint-stock company that manufactures large-scale reactor components, including pressure vessels, internal reactor parts and steam generators.

Lithuania

In December 2009, Lithuania's last reactor (RBMK) that was operating in the country was shut down, as part of its EU accession commitments. Lithuania had been trying to keep nuclear plant Ignalia 2 (1.300-MW RBMK) in operation up to 2012, but was unable to controvert the opinion of the European authorities.

An interim repository will be built on the plant's own site (AREVA contract to be paid by the European Union) to store low- and intermediate-level wastes from plant decommissioning. In March 2010, an agreement was signed with Sweden for construction of a transmission line to carry electric power to the country, pending the availability of other nuclear plants.

As a consequence of the reactor shutdown, the country's price electric power rose 31% in 2010. A proposal already exists for a reactor (Visaginas) in Lithuania under a consortium with Estonia. This is classified by the interested governments as an immediate implementation project to ensure energy security and cut down gas dependence on Russia, besides assisting in complying with European goals of greenhouse gas emission reduction.

On July 14, 2011 Lithuania selected Hitachi-GE as the supplier of the new Visaginas plant equipped with an ABWR type reactor, expected to be in operation in 2020. The contract should be signed in 2011, with the project's cost estimated at up to 5 billion Euros. Another solution for the region's energy shortage is the Russian construction proposal for 2 VVER with a capacity of 1200 MW each, located in Kaliningrad neighboring (10 Km) Lithuania and Poland. Start of construction is scheduled for April 2011 and plant operation for 2016 and 2018. Investor presentation has termed the Project a business with guaranteed customers.

On 15 Oct 2012 Lithuanians voted against a new nuclear plant at the Ignalina nuclear site, but the country's likely new rulers said no final decision has been taken and a second referendum could be held in two years. A final investment decision on whether or not to go ahead with the project is expected in 2015. Hitachi has said the new unit could be commercially operational by 2021 or 2022.

C - Africa / Middle East / Africans Countries

Construction at Barakah 1 in the UAE (Photograph courtesy of ENEC).

The African continent has huge fossil reserves and hydro sources that can be harnessed for electricity generation. Still, electrification and consumption are at very low levels, especially in rural areas, inasmuch the countries are unable to use their reserves due to extreme droughts, high oil prices, conflicts and to the general shortage of resources.

Besides presenting high losses, the existing power transmission systems are insufficient to provide the countries with the necessary support for domestic electricity distribution. There exists an urgent necessity of ensuring the quality and reliability of electric power supply for the peoples of that continent.

Nuclear power is under serious consideration in over 20 countries which do not currently have it. In the Middle East and North Africa: Gulf states including UAE, Saudi Arabia, Qatar & Kuwait, Yemen, Israel, Syria, Jordan, Egypt, Tunisia, Libya, Algeria, Morocco, Sudan. In west, central and southern Africa: Nigeria, Ghana, Senegal, Kenya, Uganda, Namibia

South Africa

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2011 (TWH)	% of total energy generated in 2011
South Africa	2	1800	0	0	12,923	5,19

South Africa’s two operating reactors (Koeberg 1 and 2 - PWR 900 MW each), produced 12, 923 TWH in 2011, about 5,19% of the electrical energy in the country.

The country has a reactor design of its own, but due to the lack of financing associated with the government’s cutback on project funding, the responsible company PBMR (Pty) Ltd - which officially belongs à Eskom (Industrial Development Corp) and Westinghouse - is in the process of liquidation. The government has invested around 1.23 billion dollars in this project, over the 11 years of the company’s existence.

Former Minister of Energy - Dipuo Peters reiterated in 2012 the government's commitment to nuclear energy and renewable sources, aimed at electricity mix diversification and greenhouse gas reduction. According to her, the Japanese accident will bring lessons that will be used on projects planned to come into operation by 2023, seeing that in the nuclear industry experiences are exchanged among the countries, to the benefit of all.

Central Nuclear Koeberg (*Photo by: Ruvan Boshoff)*

The country is planning to build 9.600 MW of new nuclear capacity over the next 2 decades, as part of the plan to double South Africa's energy supply from 25,000 MW to 50,000 MW, at a total cost estimated at 89 billion Euros. Such plan also includes wind, coal and solar energy sources. According to the minister, the country is not contemplating dropping plans for expansion of nuclear energy supply.This context was signed in October 2013, a memorandum of understanding between the South African company SEBATA (company engineering, procurement and construction management) and Westinghouse for the preparation for the potential construction of AP1000 nuclear power plants in the country.

Egypt

Egypt has not a large quantity of fuel, and forecasts are that oil and gas reserves will last no longer than 3 more decades. For these and other reasons, Egypt is expected to sign a contract with the 6 foreign consultant firms that joined the competitive bidding process intended to develop activities that will assist in the preparatory phase toward the country's first nuclear power plant.

It is expected that by 2012 authorities will have defined the type and supplier of the future reactor, inasmuch as the country is planning to build 4 nuclear power plants by 2025, with the first one coming on stream by 2019. The selected site is El-Dabaa on the Mediterranean coast.

The activities covered by such bidding process include training of teams, especially in activities concerning nuclear plant safety and monitoring, quality systems, and regulatory framework. This should allow the country to rise to international standards prior to the construction of the planned plants themselves. In addition, cooperation agreements with Russia are under way for future work in uranium prospecting and mining, specialized personnel training in regulatory matters, and nuclear construction and operation.

Egypt has 2 research reactors dedicated to activities focused on neutron radiography, neutron physics, and radioisotope production.

Ghana

Ghana has a reported population of about 24 million people. It is a Middle Income Economy. The electrical energy comes from the Akosombo Dam that provides hydro-electricity for Ghana and its neighboring countries.

The Ghana Atomic Energy Commission has said nuclear power could provide at least 10 percent of the country's installed capacity by 2020. A memorandum of cooperation was signed with Rosatom (Russia) for development of nuclear energy and infrastructure to support these

activities in the West African country.
A working group will be established to study potential joint projects and a draft framework agreement on areas of cooperation will be prepared.

Ghana has no existing commercially operational nuclear units, but since 1994 has been operating a small Chinese research reactor known as the Ghana Research Reactor-1, or GHARR-1.

Israel

Israel is not a member of the IAEA or a signatory of the Treaty on Non-Proliferation of Nuclear Weapons (NPT), but it has been reported that it develops a complete program in this field and possibly has a strong nuclear military capacity. But any information in the sensitive context of nuclear weapons is very difficult to verify, given the lack of access to countries' concrete intelligence data, which is also not the focus of this paper.

A nuclear plant for electricity generation would have no room in Israel, given the small size of its grid (10,000 MW). Notwithstanding, in March 2010, the government (minister of infrastructures) announced that the country will be developing a civil program, with the first plant planned to come into operation over the next 15 years. Israel has been developing a program dedicated to the sector of renewable energy sources.

Israel has the Negev Nuclear Research Center, 13 km from the city of Dimona (KAMAG) and the Soreq Nuclear Research Center (MAMAG) about 55 km from Tel Aviv, in which sites the country's two research reactors are operating.

Jordan

In line with its civil nuclear energy program, Jordan has signed memoranda of understanding with reactor suppliers in Canada (AECL), Japan and South Korea (Kepco) for selecting a construction site for its nuclear power station. As a result of such process, on 09/15/09 Tractebel Engineering (GDF Suez company) was chosen as a partner in carrying out nuclear technology development efforts and studies on the use of nuclear energy for production of potable water from the sea.

As it produces no oil or gas and depends on politically unstable suppliers (97% of its fuels are imported), and given the region's susceptibility to constant terrorist attacks, Jordan is planning to have 30% of its energy supplied from nuclear power up to 2030.

Much of this is driven by the discovery of uranium deposits in its territory (reserves estimated at 65,000 tonnes) which the country is planning to exploit despite the strong opposition of the United States.

The United States refuses to permit Jordan to mine and enrich its own uranium; instead, any cooperation in this area necessitates nuclear fuel purchases on the international market for the purpose of preventing, according to them, weapons proliferation problems and/or other military intentions. The country expects to begin construction of its first plant in 2014 to reach the operation of the first reactor in 2020 and second in 2025. The supplier will be Russia, winner of the international competition with model AES92 (VVER 1000).

In addition, Jordan has signed its uranium mining with Areva lasting 25 years. In December 2009, a contract was signed with South Korea for the construction of a 5 MWt research reactor intended for both radioisotope production and training of the country's scientific and skilled human resources. It is foreseen until 2016.

Image of first reactor of Jordan (KAERI)

The Fukushima accident has brought no changes to the nuclear policy of Jordan, with 2 power reactors being contemplated over the next 10 years. However, in May 2012 the lower house of parliament voted 36 to 27 in favor of a recommendation by the parliamentary Energy & Mineral Resources Committee to suspend the country's nuclear program, including uranium exploration. However, JAEC says the motion was qualified in effect to endorse its cautious proceeding.

The nuclear project is to be located in Majdal, 40 km north of Amman, and the nuclear plant design calls for the use of water from a nearby wastewater treatment facility for cooling purposes.

Namibia

Namibia has no nuclear electricity generation plants, but it is Africa's top producer of uranium and the world's fourth largest. According to governmental sources, the country will use such potential to develop its nuclear industry and to generate electricity through nuclear power plants intended to complete the country's energy mix. The policy on uranium and nuclear energy is focused on the entire fuel cycle.

In November 2012, the construction of Swakop Uranium's Husab Project has began following the signing in Beijing (China) of the engineering, procurement and construction management (EPCM) contract. Swakop Uranium is an entity owned by China Guangdong Nuclear Power Company Uranium Resources Company Limited and the China-Africa Development Fund.

Nigeria

Nigeria has no commercial nuclear plants, but does have a research reactor that began operation in 2004 at the Centre for Energy Research and Training at Ahmadu Bello University in Zaria, in the northern part of the country.

According to Nigeria's Atomic Energy Commission (NAEC), Nigeria's plans begin to build a nuclear power station until 2020 for electricity generation. To this effect, a program for recruiting and training personnel specializing in nuclear will be launched. The country is committed to adhere to all safety Standards established by international oversight bodies.

In August 2011, Russia's Rosatom and Nigeria had finalized a draft of an intergovernmental agreement to cooperate on the design, construction, operation and decommissioning of Nigeria's first nuclear power plant. Nigeria is planning to generate 1,000 megawatts of electricity through nuclear energy by 2020 and gradually increase it to 4,000 megawatts by 2030. According to Nuclear Energy Insider Mr Osaisai expects that NAEC will apply for the licensing of the approved sites by the end of 2013.

The license of the site (which can be Kogi and Akwa Ibom) is still expected for 2013 as reported by the government (pending approval of the federal executive council according to the Nigeria Atomic Energy Commission -NAEC).

Kenya

In early 2011, Kenya's National Economic and Social Council (NESC), the government’s body charged with accelerating the country’s economic growth, recommended that a nuclear program with all the necessary electricity generation framework should be initiated as a means to meet the growing domestic demand for electric power by 2020.

The Minister of Energy, Kiraitu Murungi, set up a committee of 13 specialists to prepare a detailed plan and schedule, and is looking for sites along Kenya’s coastline for the construction of a nuclear plant, with all IAEA requirements for this activity to be complied with.

Company KenGen, the largest electricity producer, is seeking partners for a 4,200 MW nuclear power project in an attempt to mitigate the problems caused by droughts, when the levels of reservoirs’ water used in hydro power generation (65% of the national electricity grid) are severely brought down.

Kenya Power has begun recruiting staff to manage its planned nuclear energy project. The company has called for applications for a project feasibility team leader, internal auditor, financial accountant, procurement officer, legal assistant, audit assistant and an ICT officer related to plans to build a nuclear energy project.

Kenay’s Energy Regulatory Commission (ERC) estimates that peak power demand in the country stands at about 1,200 MW against an installed capacity of 1,500 MW and it is projected that the country will require at least 1,800 MW of power by 2016.

Apart from South Africa, Nigeria is the only other country in sub-Saharan Africa with plans to build nuclear power plants to meet a major part of its electricity demand by 2015.

Saudi Arabia

In 2008, Saudi Arabia signed a cooperation agreement with the United States for development of a civil program for nuclear electricity generation. In February 2011, a similar agreement was signed with France, others with South Korea, the Czech Republic, the UK and with Russia. In January 2012 Saudi Arabia has added China to a growing list of countries with which it has signed nuclear cooperation agreements.

In June 2011, Saudi Arabia confirmed its plans to build 16 nuclear power reactors over the next two decades at an estimated cost of 80 billion dollars.

These reactors will be used in energy generation and water desalination; the first 2 should start operation from 2022 onwards, followed by others up to 2030. The government expects nuclear energy to reach 20% of the domestic consumption over the next 20 years.

Saudi Arabia is expected to tender for four nuclear power units in 2013 and an additional four in 2014.

Turkey

Presently, Turkey is the 17th largest economy in the world and imports most of its energy. In 2011 produced 228 TWh of electricity (thermal capacity with fossil fuel - 64% -fossil fuel and 36% renewable), to serve a population of 72 million inhabitants. The introduction of nuclear energy in Turkey dates back to the early 70s.

Along this same context, in March 2008 Turkey launched an international competitive bidding process for a 4,000 MW nuclear power plant to be built by 2015, with the possible resumption of the Akkuyo project suspended in 2000. In September 2009, Turkey's ambassador to the IAEA - Ahmet Ertay, informed that 5 VVER type reactors will be built by Russia on the Mediterranean Coast Akkuyo site, with a capacity for 5,000 MW, and that another 10,000 MW project is under study (SINOP), on a separate site yet to be licensed.

In late 2010, the agreements signed between Turkey and Russia were ratified by their respective parliaments and criteria were defined for sales of nuclear energy generated by Turkey's company TETAS, which will buy 70% of the total produced by the two first plants (1200 MW each).

Planned or proposed Reactors in Turkey

Source: WNA

Reactor/ NPP	Tipo	MWe	Construction starts	Operation begins
Akkuyu 1	VVER-1200	1200	January 2016	2021
Akkuyu 2	VVER-1200	1200		2021
Akkuyu 3	VVER-1200	1200		2022
Akkuyu 4	VVER-1200	1200		2023
Sinop 1	Atmea1	1150	2017	2023
Sinop 2	Atmea1	1150		2024
Sinop 3	Atmea1	1150		?
Sinop 4	Atmea1	1150		?

According to the terms of the 2010 contract, Atomenergoproekt JSC, a subsidiary of Rosatom Corporation will fully construct and operate (for 60 years) four 1.200 MWe PWR (VVER/491)

units with total capacity 4.800MWe, in Günlar-Akkuyu (Büyükeceli, Mersin Province) on Turkey's southeastern Mediterranean coast.
In 2012 the US$20bn construction contract of Turkey's first nuclear power plant, Akkuyu, was awarded to Rosatom and Atomstroyexport. They forecast the first plant would start operation in 2019.

In 2013 - Following a bilateral meeting between Turkey and Japan, MHI and Areva are set to win an order to build a second nuclear power plant in Turkey. Preferred negotiation rights could be awarded to the Mitsubishi-Areva consortium after the two leaders agree to cooperate on the **Sinop Project**, located on the Black Sea coast that would consist in four units and have an installed capacity of about 4.5 GW. Construction should start in 2017 and the first unit should be commissioned in 2023. Turkey has reached the final phase of talks, selecting the Japanese-French consortium Mitsubishi Heavy Industries-GDF Suez. The cost will be 22 billion dollars.

The Fukushima accident has brought no changes to the country's nuclear policy but turkish citizens raise concerns over the safety conditions of the Akkuyu project and the environmental consequences. The country will do the same tests as EU nations, even though it is not a member of the Bloc.

United Arab Emirates

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
United Arab Emirates	0	0	2	2.690	0	0

In 2008, after a large study, the government decided that to meet the growth in energy consumption in the region, the country needs to double the available capacity and the best source to meet this need would be nuclear energy.

Cooperation agreements have been signed with several countries to support a civilian nuclear energy program seeking to have in operation by 2020 three nuclear power plants of 1,500 MW each. South Korea won the international bidding for the construction of the Arab Emirates' first nuclear power station (4 APR-1400 reactors). The other competitors were AREVA (with the EPR reactor) and GE Hitachi (ABWR). The contract signed on December 27 by the Korea Electric Power Corporation (Kepco) and Emirates Nuclear Energy Corporation (ENEC) comes to 40 billion dollars and contemplates the construction of 4 nuclear units by 2020, intended to supply 25% of country's electricity.

The site selected for first nuclear power plant is Barakah or Braka, near Doha (capital of Qatar) and 240 km away from Abu Dhabi and may consist of up to 4 reactors. The work is to be initiated by 2012, it being expected that commercial operation of the first unit will start by 2017. Korean company Doosan Heavy Industries will supply the heavy components. In July 2010, the regulatory body granted the licenses for site preparation and start of fabrication of several components (thus enabling the Korean Doosan Heavy Industries to start working).

In addition, activities are under way for an international competitive bidding process intended to procure nuclear fuel for the future plant.

Barakah1 and 2- Under construction

Emirates Nuclear Energy Corp. announced August 15 that it has contracts with six companies worth $3 billion for natural uranium, concentrates, conversion and enrichment services that will supply its planned four Barakah nuclear units for up to 15 years.
Australia has signed a nuclear co-operation agreement authorizing uranium exports to the United Arab Emirates, where construction started recently on the first of four planned nuclear power reactors.

During the 55th IAEA General Conference in Vienna in September 2011, through its permanent ambassador to the IAEA, Hamad Al Ka'abi, the Arab Emirates once again confirmed their commitment to higher safety standards in implementing the country's civil nuclear energy program in cooperation with the Agency.

Construction of the first unit, Barakah-1, officially began in July 2012 when first safety concrete was poured. Barakah-1 and -2 are scheduled to be commissioned by 2017 and 2018 respectively.

A third unit is scheduled to be commissioned in 2019 and a fourth in 2020. The United Arab Emirates (UAE) has issued a law setting the liability from nuclear damage at 450 million Special Drawing Rights, equivalent to about 2.5 billion dirhams (680 million US dollars, 523 million euro).
May 2013 - Construction of the second unit, Barakah-2, officially began in May 2013 when first safety concrete was poured. The construction application for Barakah-3 and -4 was filled also.

D - Asia

Position of Asian Nuclear Power plant in operation

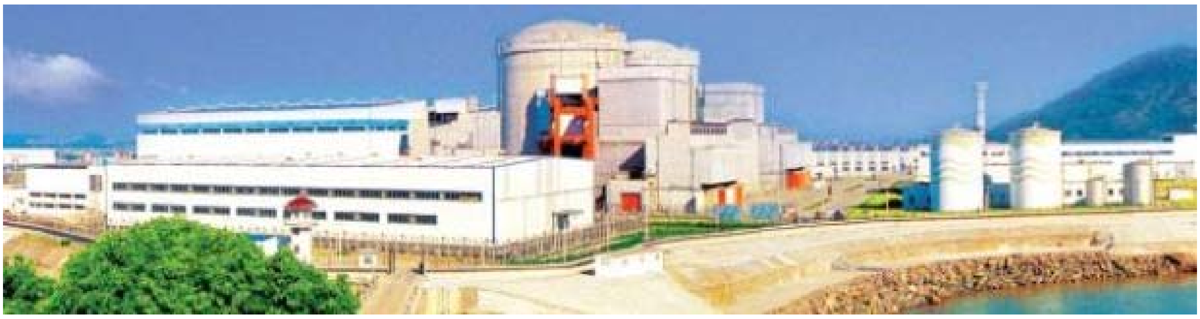
The Asia-Pacific region is strongly dependent on fossil fuels for electricity generation with around 60% of electricity generation in China, Japan, South Korea and India coming from such sources. A change in the region's generation mix is expected, with nuclear energy gaining greater prominence. Given the fast growth shown by China, the number of reactors in the region is likely to double by 2020. Today, seven countries rely on nuclear energy, a number expected to reach 21 by 2020. Until May 2013 there were 46 nuclear reactors under construction in Asia.

China

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
China	18	14.742	28	30.610	98,200	2,00

China is today the world's greatest consumer of energy (4,190 TWh in 2010), according to Nobuo Tanaka, director the International Energy Agency. China's demand for commodities and products is so big that it has a huge impact on the global market. The country has a limited supply of oil and gas, but is rich in coal, and the domestic consumption of such fuel leads to a heavy environmental pressure as to gas emissions. At present, 83% China's electricity generation come from coal-fired plants, whereas the world's equivalent is 36%. The government's plans are to lower such dependence to 15% of electricity generation, thus cutting back as emissions caused by the fossil fuels.

As far as nuclear energy is concerned, the country has, up to May 2013, 18 nuclear power plants in operation (14,742 MW) and the Chinese government contemplates the construction of 54 new plants over the next 30 years. According to the IAEA, 28 plants are now under construction (with a total capacity of 30,610 MW) and 16 new reactors have been approved for start of construction. All large vendors have already submitted offers to the Chinese government, inasmuch as this is, today, the world's biggest nuclear power business. To AREVA alone China will pay 12 billion dollars for 2 already contracted EPRs.



Unit 4 at China's Qinshan Phase II commercial operation

China's option for nuclear energy is associated with the high demand for energy and the government's strategy to substantially diversify its energy mix to prevent breakdowns in supply. The country's per capita consumption is around half of that prevailing in Brazil, but the population is nearly 7 times as high.

To meet such needs, last year China produced 87.400TWh of electricity from nuclear, which means around 1.85% of the country's electric power. The country is planning to reach 35 GW of installed nuclear capacity by 2015, 58 GW by 2020 and 70 GW by 2025. Given such capacity, China should come to 5% of electricity generation from nuclear power by 2030.

CNNC carries out extensive international cooperation in nuclear power, nuclear fuels and nuclear technology applications and has established science and technology exchanges and economic and trading relations with over 40 countries and regions including Russia, France, Germany, the United Kingdom, the United States, Canada, Japan, South Korea, Pakistan, Mongolia, Kazakhstan, Jordan, Niger, Algeria, Namibia and Australia, etc.

Atomstroyexport has confirmed a deal with China's Jiangsu Nuclear Power Corporation (JNPC) for the construction of Tianwan's power station reactors 3 and 4.

AP1000

In April 2009, the work was started at Zhejiang for Sanmen nuclear power station's Unit (PWR 1000 MW), the world's first AP1000 reactor, whose vessel was installed in September 2011 (manufactured by Korea's Doosan Heavy Industries & Construction). The design estimates a 60 years' useful life for such plant, whose commercial operation is expected for 2013. When completed, Sanmen will host 6 AP1000 reactors, with the second unit scheduled to come into operation by 2014.

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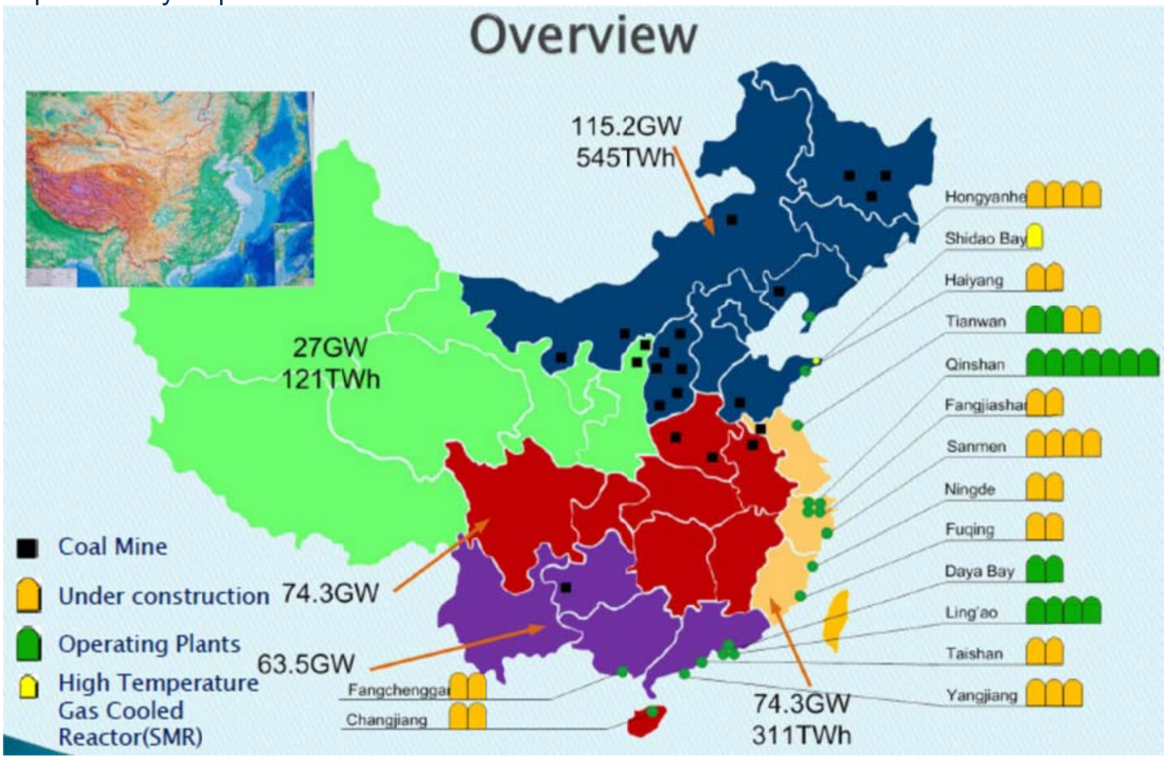


Location of Nuclear Power plant in China

Haiyang 2 (AP-1000) – maio 2012 (photo CNECC)

All of this ambitious process is heating up the Chinese nuclear industry, with companies' fast-paced diversification to cope with the government's strategy to attain self-sufficiency as quickly as possible. Today, China's Nuclear Power Institute - NPIC has 6,000 professionals on its workforce, and many more in other Chinese research institutions. A lot of mechanical engineering companies are changing their business focus to meet the country's new needs.

Yangjiang NPP

In this context, it is expected that China will annually consume around 25,000 metric tonnes of uranium as early as 2020, according to Cao Shudong, development director of China National Nuclear Corp.

Another Chinese proposal (from large COSCO shipping company) is to have container ships powered by nuclear reactors as a means to reduce world greenhouse emissions by 4%.

Nuclear wastes

In line with China's nuclear waste policy that contemplates spent-fuel reprocessing, a pilot plant for 50 metric tonnes a year, in the Gansu Province, was tested in 2006. Spent fuel from Daya Bay nuclear power plant was hauled to such pilot plant in 2004, but it has not been reported whether the plutonium content in that material was separated in the reprocessing operation. China National Nuclear Corp - CNNC is planning to have a reprocessing unit in commercial operation by 2025.

In January 2011, China announced a technology advance in nuclear fuel reprocessing that will allow full reuse of the plutonium and spent fuel from its plants, making the country self-sufficient in nuclear fuel. Reprocessing technologies are not usually shared among countries.

Qinsham 3, a Candu type reactor (PHWR) normally fuelled with natural uranium, has been using reprocessed fuel since March 2010. Such test indicates that China is beginning to find a use for its stockpile of reprocessed uranium (RepU) and is concerned about uranium supply for its uranium for its plants.

Reator Experimental Chines - CEFR
(foto : China Institute of Atomic Energy)

In this context, China's experimental (20 MWe, fast-neutron) reactor - CEFR was connected to the grid in July 2011, near Beijing. FBR reactors produce much less radiation as a by-product. The reactor was built by China's Institute of Atomic Energy with the aid of the Russian government over a decade. Now they can move on to a commercial model planned to operate by 2017.

China ordered an extensive safety inspection program for its plants in response to the Fukushima accident. Approval of new reactor projects is conditioned on the results of such safety tests.

Densely populated areas and locations more prone to geologic hazards are being ruled out as sites for new plants, which formerly were no cause for concern in China.

Tests performed on operating nuclear plants have found no safety problems and, up to October, will be applied to plants under construction. The entire safety system is under review, and no new licenses will be released until this is over, Li Ganjie, the Minister for the Environment informed.

It is likely that China's ambition to export the second-generation CPR1000 reactor model has been abandoned, because, despite its lower cost, it would face some market problems for failing to meet the more up-to-date safety standards. A few projects may be delayed, but China is still committed to the 58 nuclear GW planned for 2020, according to Xu Yuming, Secretary General of China's Nuclear Energy Association (May 2011).

India

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
India	20	4.391	7	4.824	29,664	3,60

India faces the extraordinary challenges of a huge and growing population, a rapidly developing economy and sprawling outdated infrastructure. In July and August 2012, two enormous outages affected more than 600 millions people.

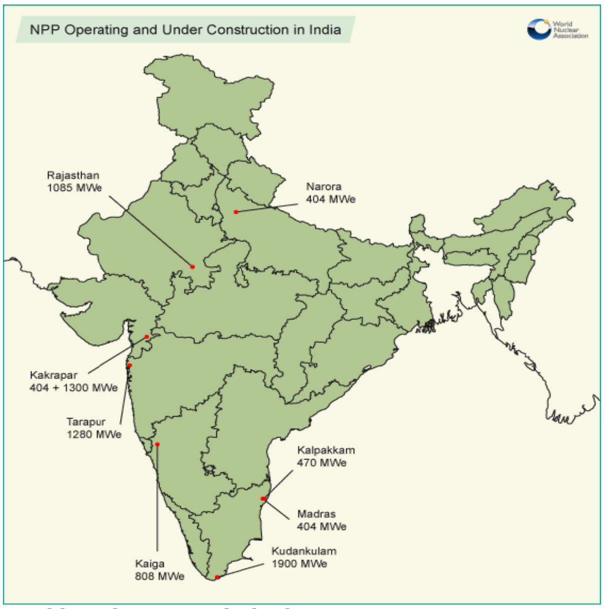
India has 20 nuclear reactors in operation (4,391 MW) which, in 2011, produced around 3.68% of the country's electricity, or 28.948 TWh. At present there exist 7 plants under construction (4824 MW), and an additional ten 700 MW PHWRs and ten 1000 MW LWRs are officially planned and expected to start construction by 2012. The country's installed capacity is estimated to reach 10,080 MW by 2017, at the completion of all construction projects.

In India, around 40% of the population (450 million people) has no access to electricity. The country meets most of its electricity needs with coal (68%), hydro power (15%) and gas (8%), but to cope with the gigantic energy needs of a country with a population above 1.15 billion, and whose consumption is only 4% of the United States' per capita electricity or 25% of Brazil's per capita consumption, much more is needed. The world nuclear suppliers market expects that 25 new reactors (around 20 GW) will be ordered up to 2020. India has a considerable quantity of thorium (290,000 tons). According to India's power minister Mr Sushilkumar Shinde the Country has plans to build nuclear power generation capacity of 63 GW during the next 20 year.

Infrastructure, generation, transmission and distribution requirements are expected to necessitate governmental spending of 150 billion dollars, according to a consultant KPMG. India develops its own program of nuclear electricity generation with emphasis on PHWR reactors (18 units), mostly with 220 MW capacity. It also has 2 BWR reactors (150 MW each).

India is not a signatory to the NPT – Nuclear Non-Proliferation Treaty, and on account of its nuclear weapons program, it had been facing problems of nuclear fuel supply for its plants. Out of the reactors in operation and under construction, only 6 are open to inspections by the IAEA. Since 2008, supply of sensitive material to India has been released. Accordingly, American companies are authorized to supply India with nuclear material, equipment and technology.

International isolation due to non-participation in the NPT led India to develop its own technology and internally train its specialists. Today, the country is prepare to provide labor to a number of companies worldwide, and its industry is expanding and setting up joint ventures for international supply of nuclear components and services, besides Indian technology reactors.



World Nuclear Association's map

In September 2009 the country announced its intention to become an exporter of power reactors of its own design - Advanced Heavy Water Reactor (AHWR), fuelled with low enrichment uranium, and competing with other suppliers. India is a huge market not to be neglected, it also being expected that the country will become a large buyer of technology and fuel. Uranium consumption tends to be significant, seeing that the country imports 70% of its energy needs, which is equal to importing 90% of the country's demand for fuel. Confirming this position, in August 2010 NPCIL - Nuclear Power Corporation of India Limited signed contracts for importing uranium from the following companies: Areva (300 MT of uranium concentrate); Russia's Tvel Corporation (58 MT of enriched uranium dioxide (pellets) and 2,000 MT of natural uranium oxide (pellets); and Kazakhstan's NAC Kazatomprom (2100 MT natural uranium mineral.

The government is also developing a 7,000 ton nuclear-powered submarine project, built in India and based on Russian Akula I model (planned to be 5 units). In July 2011, Russia, supplier of 70% of war equipment to India, announced it will deliver the first submarine to India by December 2011.

Kudankulam -Two reactors (950 MW-VVER) under construction at India. Reactor 1 was connected to the national grid October 2013 - (Photo: Atomstroyexport)

Under India's waste management system, the treatment is done on the plants' own site and a nuclear waste reprocessing system, currently in an advanced stage, can very much help in mitigating the country's energy shortage problem. PHWR plants' fuel is reprocessed at the Bhabha Atomic Research Centre (BARC) in Trombay, Tarapur and Kalpakkam to extract the plutonium used in "FAST BREEDER" reactors. The country storages the material resulting from other plants' fuel reprocessing.

In August 2011, the civil nuclear cooperation agreement with South Korea was signed, which allows Korean companies to participate in India's nuclear projects. This is the ninth agreement signed by India with other countries, after the NSG - Nuclear Suppliers Group's agreements were relaxed. The other agreements were signed with France, U.S.A., Russia, Canada, Mongolia, Kazakhstan, Argentina and Namibia.

India has a solid program of nuclear power plant construction and seeks to strengthen its nuclear electricity generating system with the addition of 470 GW by 2050 (39 more plants projected). The government proposes building additional nuclear capacity to cope with the constant, severe rationing India has been going through. According to the authorities, use of coal is essential for electric power generation in the country, where consumption is rising 6% a year, although 40% of households have no access to this convenience.

The government reserved the right to maintain the nuclear option, guaranteeing it to be the best energy source, mainly with respect to the reduction of greenhouse gas emissions - GHG. In August/11, Prime Minister Manmohan Singh reaffirmed his administration's commitment to the expansion of nuclear electricity generation as a means to realize country's desired growth and development without the production of GHG.

The accident in Japan has raised doubts for the inhabitants and brought protests on nuclear sites supposedly more prone to earthquakes and floods. The authorities have promised to review these projects' safety aspects and mechanisms for response to severe accidents, and apply the best, state-of-the-art international safety criteria.

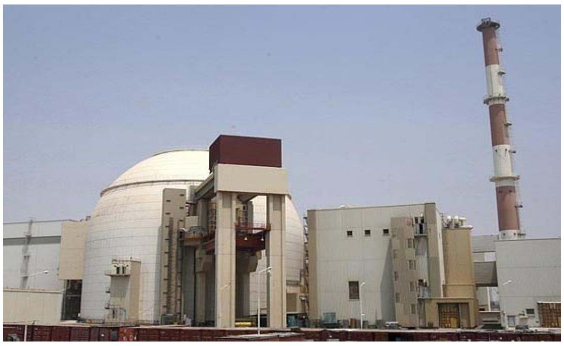
Iran

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Iran	1	1.000	0	0	1,33	0,6

Iran's Nuclear Program dates from the late 1950s. By the 1960s, the United States had supplied the Iranians with a small research reactor, and signed an agreement in 1957 pledging to provide Iran nuclear devices, equipment and training specialists. Before the Islamic Revolution (1979) it was foreseen 23 reactors for electricity production. Iran has a plant in operation (Bushehr, PWR 1000 MW) connected to the grid on September 4, 2011, and has produced in 2012 1,33 TWh from nuclear power. Some 70% of its electricity was from gas and 25.5% from oil, both of which it has in abundance. The per capita consumption was of about 2000 kWh/yr.

The construction work by a German consortium (Siemens/KWU) started in 1975 and was stopped in 1980, after the Islamic Revolution (1979) when Germany joined the American embargo and broke the contracts in force at that time. The construction was resumed, after years of stoppage, with the aid of Russia and the approval from the IAEA, and completed after several delays caused by a number of reasons. Plant operation, fuel supply and waste storage will be handled by Russia over the next 3 years.

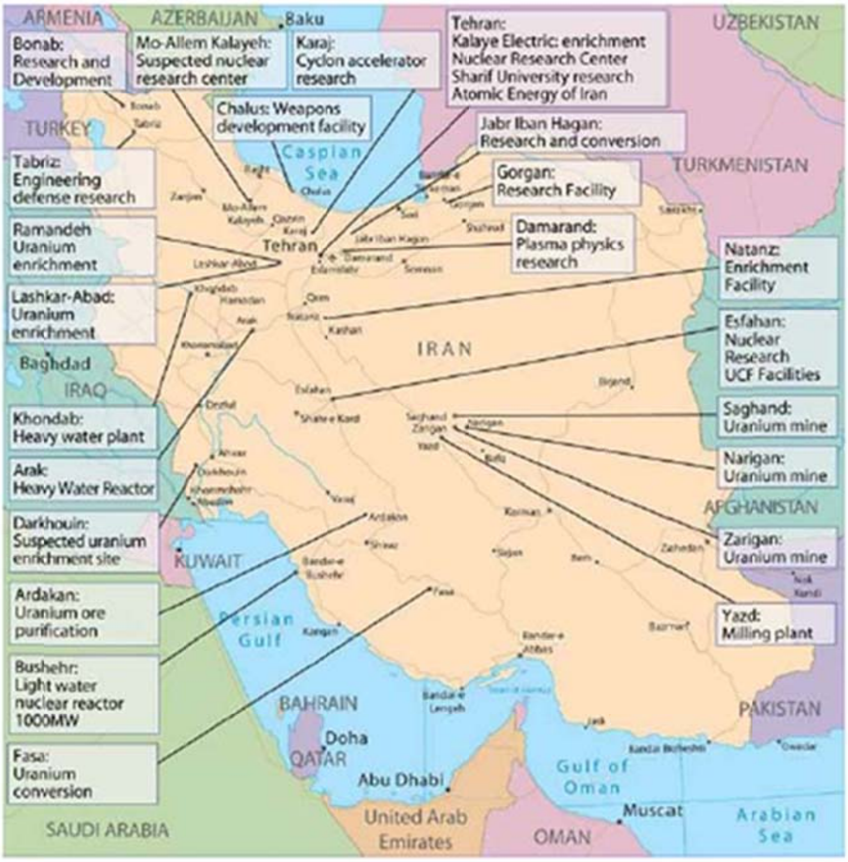
As informed by the government, the country intends to build 5 additional nuclear reactors to supply around 10% of the country's electricity requirements, thus coping with the rationing problems have been going on in the region. The two first would be 360 MWe LWR in Darkhovin/ Darkhoveyn (river Karun - Khuzestan province and another one would be in the same site of Bushehr.

NPP Bushehr, Iran (photo : Atomenergoproekt)

Iran's president said on July 03, 2013 that preliminary talks for Russia to help build a new Iranian nuclear power plant had been completed, and the project just needed Russian President Vladimir Putin's approval to go ahead.

Iran Nuclear Sites



Sites with nuclear activities in Iran

Under Iran's nuclear program, uranium is processed and according to the IAEA, has been enriched to less than 5%. Iran has faced problems with the international community, which alleges the country's enrichment process is associated with war plans and that it has already sufficient material for the construction of an atomic bomb. The country denies such intentions, inasmuch as nuclear weapon fabrication requires an enrichment level of around 90%, and that all of its uranium is destined for future electricity generation. Anyway, according to the WNA - World Nuclear Association, Iran's known uranium mineral resources are not significant.

The International Atomic Energy Agency is proposing an agreement whereby Iran would send approximately 75 % of its stockpile of around 1.5 tons of low enrichment uranium (LEU) for conversion abroad (probably in Russia) and transformation into fuel for a research reactor in Teheran.

According to the latest IAEA report, presented in February 2013, Iran currently produces uranium enriched to 3.5% or 20% in two complex, Fordo and Natanz.

Japan

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2011 (TWH)	% of total energy generated in 2011
Japan	50	44.114	2	2.600	156,182	18,14

The country as a whole depends on external sources of primary energy by 96%.

Japan has 50 reactors (44,114 MW) in operating condition. Of these only two energy produced in 2012. Were produced 17,350 TWh in 2012, which represented 2.1% of the country's energy. There are 2 power plants under construction (Shimane Ohma 3 and 1 - ABWR 1300 MW each) and nine reactors permanently shut. There are plans for extensions of life and power.

In May 2012 all 50 Japanese nuclear power plants were off. In September only 2 (Ohi reactors 3 and 4) had returned to operation and were generating power to the grid. The other reactors will be restarted only after completion and approval of Stress Tests. It is also necessary to return the reactor to operation an approval given by the local governments.

The shutdown of nuclear reactors in Japan led to a strong rise in oil imports to feed its oil-fired power plants, necessary to fill the gap of lower electricity supplied by nuclear energy. This may also help explain why the country is now running a trade deficit for the first time over the past five years. This energetic condition just gets worse the high level of debt, will most likely lead to a restart of nuclear reactors. In fact, the new Prime Minister Shinzo Abe has already spoken a lot about this subject.

The Fukushima-Daiichi accident

At 14h:46 min of March 11, 2011, local time, northeast Japan was hit by an earthquake of 9.0 degrees on the Richter scale. The epicenter was very near the coastline and a few kilometers below the earth's crust. It was the largest earthquake ever recorded to have hit a highly industrialized, densely populated area. Even for a high earthquake risk-prone country whose culture and technology have adapted to make such risk acceptable, such event, on a probability scale of 1 in every 1,000 years, the disaster exceeded all the response capacity developed by Japan over centuries.

Most buildings and all industrial facilities with risks of explosion and release of toxic products to the environment, such as oil refineries, fuel storage areas, thermal power plants, and chemical facilities located in the affected region collapsed immediately, causing thousands of deaths and environmental damage yet to be entirely quantified. Roads and power transmission lines were also damaged on several scale degrees.

The 14 nuclear power units in the affected region's three nuclear power stations resisted the titanic forces released by nature. All of them were automatically shut down and put in safe cool-down mode with diesel-generators, after the loss of all external power supply.

The tsunami that followed the event broke down the entire emergency diesel generator system intended to cool down the 4 reactors of the Fukushima-Daiichi nuclear power station, leading them to a major nuclear accident status with total loss of the 4 reactors involved, due to reactor core melt-down, with release of radioactivity to the environment after hydrogen explosions, but without nuclear accident victims. There were 4 deaths for other reasons than the accident or nuclear radiation.

The need for removing the populations near the plant area became imperious and a full-scale nuclear emergency plan was mobilized at a time the country was devastated and more than 18,000 died as a consequence of the earthquake, tsunami, fires, and industrial explosions, besides the more than 5,000 missing persons. There existed no infrastructure available for the work of emergency teams; notwithstanding, thanks to the population's preparedness, the authorities, little by little, are dominating the situation.

NPP Fukushima-Daiichi after the first wave tsunami

International aid through a network of countries coordinated by the IAEA has given specialized assistance for radiation release events and, in the meantime, all learn from the event. In addition to the losses of human lives, Japan will be facing economic losses from industry's inactivity caused by breakdowns, unavailability of infrastructures or power failures triggered by the disaster.

On June 20, 2011 Japanese government through the Minister of Industry, Kaieda, decided that, except for Fukushima's 6 units and Hamaoca's 2 units, all nuclear power plants are safe to continue operating in the country. Safety measures for severe accidents are being implemented all over the country, at a time Japan cannot afford to do without this energy.

The decisions to be taken by Japan on continuing the use of nuclear energy will have to take into consideration the lack of available energy options and the cost of such decisions for a population already extremely disturbed. The Ministry of Economy, Trade and Industry estimated that replacing nuclear energy with another thermal source would cost the government 3 trillion yens or 37 billion dollars a year (around 0.7% of the Japanese GDP). The best energy mix for Japan is still under discussion and no decision has yet been taken. Anyway, the country is enforcing all agreements signed in line with the ongoing nuclear export policy, even though this has been on hold internally.

The government is trying to develop a long-term energy mix program. The decision on the country's 2030 energy mix will be taken by September among three scenarios where nuclear shares vary from zero to between 20% and 25%. There are calculations where a plan to generate 20% of Japan's power by onshore wind farms in 2030 would require an area comparable to that of Kyushu Island (one of Japan's four main islands, which is 42,191 square kilometers or 16,032 square miles). Japan's high population density can lead to a not-in-my-backyard reaction from residents, which might not just be against nuclear power but might oppose any power project.

NPP Fukushima-Daiichi Sept. 2013 (photo Kyodo News)

To make up for its lack of available nuclear generation, Japan was forced to import fuel for thermal power generation such as oil, gas, and coal, with additional expenses of about 4,3 trillion yen (55 billion US dollars, 42 billion euro) a year.

The greenhouse gas discharges will increase by about 1.2 gigatones a year as a direct result of the shutdown of many of Japan's nuclear units.

Another consequence was that government has asked households and businesses for power savings of 15 percent in the area served by Kansai Electric Power Company (Kepco) that operates 11 reactors - Ohi (four units), Mihama (3) and Takahama (4). According to a government statement cuts of 5-10 percent have also been requested in other parts of western Japan.

The government is conducting outreach work in the affected areas to dispel people's misinformation and sense of insecurity prevailing in this process.

Fukushima accident was an extremely serious event, but one that has not produced a single fatality. According to radiation specialists, the emissions from the event have not reached levels capable of causing irreparable damage to the environment or health of the population (even for the workers involved in emergency procedures). The company operating the nuclear power station – Tepco examined 3700 workers; out of these, 127 received some dose of radiation, but none of them is in risk of an immediate disease on account of radiation. In 20 or 30 years, the possibility exists (up to 5%) for them to develop some illness if they continue to expose themselves to radiation due to accumulated doses.

Japan's Electric Power Development Company Limited (J-Power) has announced that it plans to resume the construction of its Ohma nuclear power plant in Aomori prefecture, northern Japan. Work on the Ohma nuclear power plant, which J-Power said was around 40 percent complete, was suspended following the Great East Japan Earthquake of 11 March 2011 that resulted in the nuclear accident at Fukushima-Daiichi. Nowadays a civil engineering company is excavating earth to build canals for seawater intake and discharge systems, and vendor Hitachi-GE Nuclear Energy Ltd. is assembling "small" plant equipment at a workshop on the plant site in the town of Ohma in Aomori prefecture. There are a workforce now of about 1,000 people.

Kyushu EPC hopes it can restart its two Sendai units around July and two of its Genkai units by January 2014, Kyushu said April 2. Kansai EPC hopes restart Takahama-3 and -4 in October 2013. From the new reference scenario comes six reactors restart by end 2013, 16 other reactor restart by the end of 2014 with 7 months of operation on average generating 73 TWh of electricity.

Japan's nine utilities with atomic plants reported combined losses of 1.59 trillion yen ($16 billion) in the fiscal year 2012 ended March 31, 2013. Only Hokuriku Electric Power Co. posted a profit, ending the year 100 million yen ahead, and only two reactors are currently running, both belonging to Kansai Electric Power Co.

Nuclear Waste

Japan reprocesses its nuclear wastes in reprocessing plants located in France (La Hague) and in the United Kingdom, but is building its own commercial reprocessing plant in Rokkasho-mura, in Honshu Island. The plant's test run was started on March 31, 2006 and commercial operation was planned for 2009, but was delayed. Activities include reprocessing of 800 tons of spent uranium and the production of 4 tons of plutonium which, combined with uranium will be converted into MOX fuel for the country's nuclear power plants. Such fuel has already been tested and approved for use in Japanese nuclear power plants.

In May 2009, the first MOX shipment from the Melox fuel fabrication plant in France arrived in Japan to feed Genkai-3 plant, which started commercial operation in November 2009. By January 2011 there existed already 4 plants using this fuel.

About 5% of the content of MOX fuel is plutonium recovered from fuel already burnt in nuclear generating reactors. Recycling this material is the method to increase the energy it can produce by 12%, while unfissioned uranium is also recovered and reused, increasing the available energy available by 22%. Such process also allows the separation of the most radioactive nuclear fission products, thereby reducing the volumes of dangerous wastes by 60%.

Japan imports more than 90% of its energy requirements. It has no uranium in its territory. Today, its major energy source is plutonium from the reprocessing of nuclear plants' wastes that the country has stockpiled since 1999.

Such type of recycling constitutes the basis of the nuclear fuel cycle in Japan, a policy that allows the country to obtain maximum benefit from uranium imports.

In July 2010, Japanese companies Tokyo Electric Power, Chubu Electric Power, Kansai Electric Power, Toshiba, Mitsubishi Heavy Industries, and Hitachi informed that they were planning to set up a new business organization (International Nuclear Energy Development of Japan) to export nuclear power projects to emerging countries, but the Fukushima accident is likely to change this prospect.

Kazakhstan

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Kazakhstan	0	0	0	0	0	0

Kazakhstan has no electricity generating plants, but only one research reactor at the Institute of Nuclear Physics, near Almaty. Due to its large uranium production capacity (world's largest producer of uranium ore) Kazakhstan holds a great weight in the nuclear industry. The country is capable of converting high enriched (HEU) into low enriched uranium (LEU) in its Ulba plant (Ulba Metallurgical Plant in Ust-Kamenogorsk), as it did in August 2011 when 33 kg of HEU were converted into LEU, as reported by the U.S. National Nuclear Security Administration - NNSA) which is cooperating with Kazakhstan to modify the research reactor and render it capable of using LEU fuel.

Minister of Industry and New Technologies Asset Isekeshev confirmed that, although the construction of a nuclear power plant is very much on the agenda, it is seen as a long-term objective and that no decisions have yet been made on the type of reactor, the site or the timing of the project. A Russian-supplied BN-350 fast reactor operated at Aktau on the Caspian Sea coast from 1972 to 1999. A project to build smaller Russian-designed nuclear reactors at Aktau has been under consideration for several years, and feasibility studies and environmental reviews have been carried out. Plans for nuclear plants including large light-water reactors for the southern region, smaller units in western parts and smaller cogeneration units in regional cities have been under discussion for several years. In 2010 a trio of Japanese companies signed a memorandum of understanding on a feasibility study for the construction of a nuclear plant, with Lake Balkash in eastern Kazakhstan mooted as a likely location for a plant based on advanced boiling water reactor technology.

Pakistan

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Pakistan	3	725	2	630	5,271	5.34

Electricity generated in Pakistan is about ~62% from fossil fuel and ~33% from hydroelectric power for the for the remainder Pakistan has three operating nuclear power plants (Chasnupp 1 and 2, PWR 300 MW each and Kanupp, PHWR - 125 MW) in the Punjabe region. There are two reactors under construction (Chasnupp 3 and 4, PWR, 315 MW each one). In 2012, 5.271 TWh of electricity from nuclear source were generated, about 5.34% of the country's total in the period.

The country signed a contract with China (China National Nuclear Corporation - CNNC) for the fifth unit at Chasnupp not yet in construction.

In August 2013 a new contract was signed, now for the Karachi Coastal Nuclear Power Project in Pakistan which comprising two ACP1000 units. The order marks the first foreign purchase of the Chinese reactor design. The foreseen cost is about 9,5 billion dollars and construction could begging in 2015.

NPP Chasnupp - Pakistan (photo Rosatom)

The country is not a signatory to the NPT and conducts a nuclear weapons program independent of the civil electricity generation program, which uses the country's sources of natural uranium. The existing conflict with India, which has nuclear weapons itself, holds the entire region in permanent tension, with a high risk of nuclear conflict, according to international analysts. In July 2011 the country was reported to be seeking to increase its arsenal of nuclear weapons with more air-to-air and surface-to-air missiles, in line with its plan for strategic-nuclear-weapons parity with other countries holding nuclear weapons in the region.

Pakistan's power stations have a combined capacity of about 20,000 megawatts, which should be enough to cover the country's electricity needs. However, the companies managing power stations are unable to run them at full capacity because of a financial deficit caused by public sector users who have not paid their bills in years. A gas pipeline from Iran, which is potentially capable of plugging the supply gap, has been completed on the Iranian side of the border, but not on the Pakistani side.

Nuclear Power Reactors Under Construction, Planned and Proposed				
Reactor	**Type**	**MWe gross**	**Construction Start**	**Planned Commercial**
Chashma 3	CNP-300	340	May 2011	Dec 2016
Chashma 4	CNP-300	340	Dec 2011	October 2017
Chashma 5	PWR	1000?		
Karachi coastal 1&2	ACP1000	1100x2	late 2014	
Total (5)				

In June 2010 an agreement with China was announced that will allow the construction of two new reactors for 340 MW each. The cost is estimated at 2.4 billion dollars and the project will strategically help Pakistan in reducing its chronic shortage of electric power.

Nuclear wastes are treated and stored at the nuclear power plants themselves. There are plans for construction of a repository for long-term storage of nuclear wastes.

South Korea

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
South Korea	23	20.700	5	6,320	143,549	30.04

South Korea is Asia's fourth largest economy, but has no energy sources in its territory, importing around 97% of its needs, including all the oil and uranium it uses. The country is making efforts to reduce its dependence on fossil fuels and thus diversify the national electricity mix. At present, coal is the country's top electricity generating source, supplying 42% of Korea's power grid. The per capita electricity consumption is about 3 times as high as that of Brazil.

South Korea has 23 reactors in operation (20,700 MW installed capacity). In 2012, these nuclear power plants produced 143.549 TWh, accounting for around 34.64 % of the country's electricity consumption. Five plant projects are under way, that could reach to 30 GW by 2015, it being noted that approximately 6,320 MW relate to ongoing construction and an additional 3,000 MW will ensue from signed contracts nearing start of construction. The latest plants to come into commercial operation were Shin-Kori 2 (PWR - 997 MW) and Shin-Wolsong-1 with a Korean design (Improved Korean Standard Nuclear Plant - OPR 1000). Up to 2024, according to the Korean government, eight new plants should be built in addition to those currently under construction.

The country's energy policy favors nuclear initiatives, taking into consideration the safety and reliability of energy supply, inasmuch as South Korea has no energy sources in its territory.

Shin-Kori 1 and 2 - Photo: KHNP (Korea Hidro and Nuclear Power)

Although it has no uranium or enrichment facility in its territory, Korea is engaged in the production of its own nuclear fuel and also undertakes nuclear waste management activities with locally developed technology.

Korea participates in research work on several advanced reactor models (modular, ITER, fast breeder, high-temperature reactors).

The government seeks to win 20% of world's reactor supply market up to 2030. It has also announced plans to train 2,800 new nuclear engineers in order to ensure technology self-sufficiency and meet industry's demand for skilled manpower.

The country has also competed internationally in offering nuclear services

and studies, and in December 2009 was the winner in the Arab Emirates' bidding process for the supply of 4 1400MW reactors, a 40 billion dollars business.
After Korea obtained the first nuclear plant order outside of its territory, Korean inhabitants' perception of nuclear energy has improved significantly, as indicated by the latest opinion surveys (88.4 % favor the development of nuclear industry).

So far no decision has been taken on what to do with the country's spent fuel. Reprocessing is a possible option, provided consultation and negotiations are conducted with the United States, in line with the existing cooperation agreement between the countries.

Developing a new technology called "pyroprocessing" that generates no plutonium in reprocessing, is under study and will likely be the solution for reuse of nuclear fuel. The decision should be taken soon, inasmuch as the country's spent-fuel stockpiling capacity will be used up by 2016. South Korea's demand for electricity has been growing 4% per year for a decade, and technology export plans are in place that contemplate sales of up to 80 reactors by 2030. Such goal appears to have been facilitated by reactor sales to the Arab Emirates.


NPP Shin-Wolsong 1 and 2 - Image AIEA

Despite the fall in Korean public satisfaction with nuclear energy due to the Fukushima accident, the forecasts on new reactors indicate 9 units against the previous projection 20. The country is planning to go on with its nuclear expansion, and even such old plants as Kori 1 (1978) keep generating electricity. In July 2011, an international commission of nuclear experts from the IAEA visited Korea to assess good practices developed in Korea. Recommendations for improvements were made in the light of the Fukushima event, and no non-conformances were found that might compromise the safe operation of the plants.

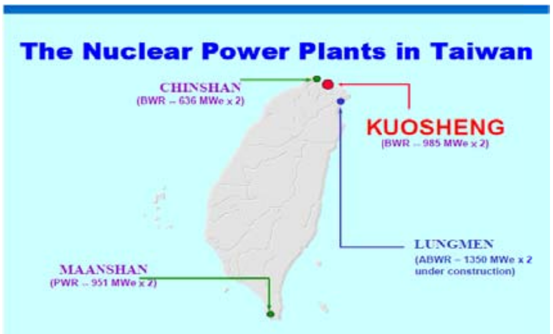
In August 2011, the pressure vessel of Shin-Kori nuclear power plant's unit 4 was installed in its final position. This is the second PR-1400 under construction (Kepco design reactor, supplied by Doosan Heavy Industries), and commercial operation is scheduled for September 2014.

Taiwan

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2012 (TWH)	% of total energy generated in 2012
Taiwan	6	4.980	2	2.600	38,887	18.37

Taiwan has 6 plants in operation (2 PWR and 4 BWR) and another 2 under construction (PHWR 1300 MW). According to IAEA, electricity production in 2012 was 38.887 TWh, accounting for 18,37 % of the country's electricity.

Chinshan plants 1 and 2 (BWR 636 MW each) started operation in 1978 and 1979 respectively. Kuosheng 1 and 2 (BWR 985 MW each). Maanshan plants are PWRs with 951 MW each.



Location of NPP in Taiwan

The government of Taiwan set up a committee to establish a multi-discipline mechanism of nuclear safety reviews and emergency preparedness and response at nuclear power plants. In the light of the Fukushima events, the government is especially concerned about nuclear plants on the coastline of China, which are very close to Taiwan, and on which they have no jurisdiction. A proposal and invitation have been made for the two countries to work together on this issue.

Vietnam

In May 2010 the prime minister made known plans to build 8 reactors. Plant 1 (Ninh Thuan Nuclear Power Plant 1, with two reactors) will be located in Phuoc Dinh Commune, Ninh Phuoc district, and Plant 2 (Ninh Thuan Plant 2, with two reactors) in Vinh Hai Commune, Ninh Hai district. In all Plants the capacity could be expanded for 4 reactors.

According to the Director of the Vietnam Agency for Nuclear Safety and Radiation, Plant 1 - with 2000 MW capacity - will be based on Russian technology. In addition, memoranda have already been signed on training for the country's new specialists. The construction is scheduled to start by 2014.

Reactors Planned and Proposed up to 2027 - Vietnam

Location	Reactor (province)	Reactor type	MWe gross	construction	operation
Phuoc Dinh	Ninh Thuan 1-1	VVER-1000	1000	2014	2020
	Ninh Thuan 1-2	VVER-1000	1000	2015	2021
	Ninh Thuan 1-3	VVER-1000	1000		2024
	Ninh Thuan 1-4	VVER-1000	1000		20125
Vinh Hai	Ninh Thuan 2-1	Gen III Japonesa (?)	1000	2015	2021
	Ninh Thuan 2-2	Gen III Japonesa (?)	1000	2015	2022
	Ninh Thuan 2-3	Gen III Japonesa (?)	1000		2026
	Ninh Thuan 2-4	Gen III Japonesa (?)	1000		2027

Companies Toshiba, Mitsubishi Heavy Industries and Hitachi Ltd have set up a consortium with the Japanese government to participate in the competitive bidding for the second nuclear power plant.

Korean companies have also submitted a cooperative bid for construction of the nuclear plant project.

The IAEA has reported that Vietnam is well prepared to start developing a nuclear fleet and that the agency will support the country's efforts to work out safety and emergency response procedures. At present, a team of more than 800 persons are working in Vietnamese energy, radiology and nuclear safety institutes.

In spite of delays and cut-backs on projects, authorities have announced that plans will proceed to build at least 4 reactors. All large suppliers (Chinese, Korean, French, Russian, Japanese and American) are actively working to close deals on these projects.

Japan, through Japan Atomic Power Company (JAPC), signed a contract with Electricity of Vietnam (EVN) on 09/28/2011 for a feasibility study on the construction of the first nuclear power plant. In July 2013 the parties agreed to "accelerate cooperation to specify the project," which would be a major step towards a contract.

Asia – Others

The Philippines, Indonesia and Malaysia are in the process of reviving their old nuclear power programs.

Malaysia has the green light from its population, in support for the construction of nuclear power plants. The country is in the process reconstructing the necessary technical knowledge through technical visits and training programs on nuclear power plant design, construction and operation. Relevant studies for selection of a suitable site have already been commissioned by the government. The country is strongly dependent on gas (64%) and coal (25%) and intends to diversify its electricity mix.

In the case of the **Philippines**, early on, a group of experts from the IAEA was invited to organize a multi-disciplinary and independent process to determine if its old nuclear Bataan Nuclear Power Plant (ready, but never put into operation) can be safely started, as a local alternative for energy generation. At present, a contract with Korean company Kepco is in operation for the conduct of such studies.

Philippines - Bataan Nuclear Power Plant -photo IAEA
Ready – has never operate

Indonesia, although considering itself prepared, is focused on first getting its population familiarized with nuclear energy, leaving to the future any plan to build a nuclear power plant, according to the Minister of Research and Technology, Syamsa Ardisasmita.

Bangladesh signed an agreement with Russia on November 1, 2011 for the construction of two 1,000 MW nuclear power plants in the Rooppur region, northwest of Bangladesh. The agreement also includes supply of fuel and management of plant's waste (spent fuel) which will be taken back to Russia. The country’s recent growth and limited availability of energy (existing gas reserves are nearly over) have led the government to close this 3 billion dollar business deal. In 2007 the country was given IAEA’s approval for its nuclear project.

In September 2011, the Ministry of Foreign Affairs of Bangladesh, Dipu Moni, informed that the country should have its first plant operable by 2022 or 2023. Bangladesh proceeds with its nuclear program with the aim of ensuring adequate electricity supply after 2020.

The government is conducting a detailed study on the regulatory framework of the country’s nuclear program, and has held talks with the IAEA and independent consultants in this connection. Bangladesh also plans to sign international agreements concerning a civil nuclear power program.

In 29 July 2013 Rosatom said it plans to launch pre-construction work for installing a 2,000 MW nuclear power plant at Rooppur in Pabna (Bangladesh) in early August 2013. The Russian company will build, operate and provide fuel to the project. Atomstroyexport will start a series of tests under a US$46m contract, while the Bangladesh Atomic Energy Commission (BAEC) will also conduct tests on their own. The tests will include feasibility evaluation, environment impact assessment, development and engineering survey, development of the comprehensive program of engineering survey, anthropogenic conditions at the project area and site, and engineering and hydro-meteorological survey.

E - Australia

Population: 23.6 Million; **GDP Growth Rate:** 3.6%/year; **CO2 Emissions:** 15.3 tCO2/capita
Energy independence:100%; **Total Consumption/GDP:** 88 (2005=100) ;

Australia is the world's ninth-largest energy producer and enjoys the benefit of abundant and diverse energy resources. The Australian continent is rich in uranium, attending for about 40% of all economical reserves in world.

Australia has no commercial nuclear plants, but the Australian Nuclear Science and Technology Organization does operate the Opal research reactor near Sydney.

However, due to political and other constraints the industry has not expanded enough and Australia currently supplies less than 20 percent of the uranium the world needs.

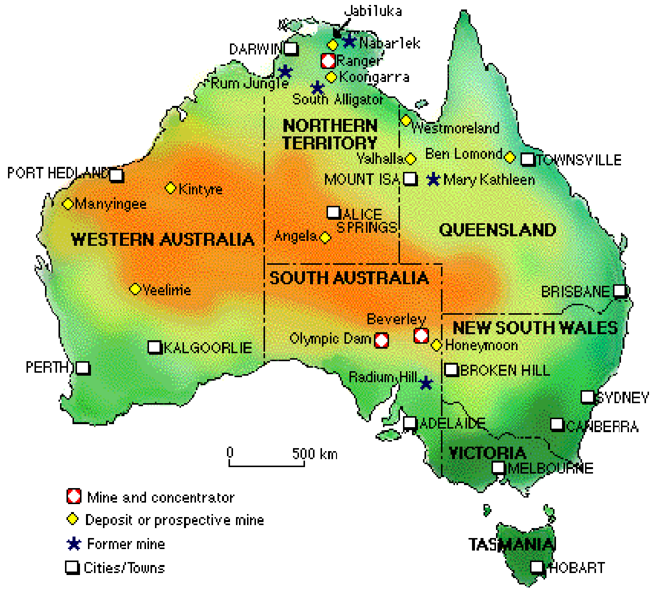
Recently Australia has signed a nuclear co-operation agreement authorizing uranium exports to the United Arab Emirates, where construction started on the first of four planned nuclear power reactors. The Australia's foreign ministry said that the agreement, which still needs to be approved by parliament, covers conditions for supply of nuclear material, components related to nuclear technology and associated equipment for use in a domestic power industry.

Another important agreement was the one signed by BHP Billiton Company, an Australia-based mining, to sell its Yeelirrie uranium deposit (resources of approximately 139 million pounds of U3O8) to Canadian uranium producer CAMECO Corporation. The deposit will cost to CAMECO 430 million US dollars (343 million euro). As usual the agreement is pending relevant approvals from the Australian Foreign Investment Review Board and the government of Western Australia. Yeelirrie is reputedly the world's largest sedimentary deposit of its kind.

Australia's Uranium – (WNA *August 2013)*

Australia's uranium has been mined since 1954, and four mines are currently operating. More are planned. Australia's known uranium resources are the world's largest - 31% of the world total.

In 2012 Australia produced 8,244 tonnes of U3O8 (equivalent to 6,991 tons of natural uranium). It is the world's third-ranking producer, behind Kazakhstan and Canada.



V – Commercial Agreements and Nuclear Cooperation

Countries and governments associate according to their needs and strategies, always seeking higher profits and/or security for their energy supply. Report of the United Nations Agency for Trade and Development (UNCTAD) confirms the growing trend of multinational lean on some 3,200 international investment agreements exist. While not exhausting the subject, the following are some publicly known signed agreements.

United States and Others:

United States – China

The United States (EXELON Company) and China (CNNC) have signed an agreement for for civil nuclear cooperation, whereby senior instructors from Excelon will train approximately 200 Chinese management and nuclear plant operation personnel in the best practices developed by the American company.

United States – Arab Emirates

The United States and the Arab Emirates have signed an agreement for civil nuclear cooperation whereby the Emirates undertake not to promote a uranium enrichment program of its own or to reprocess uranium.

United States – Japan

Westinghouse Electric Company and Toshiba Corporation have announced the formation of **BWRPLUS**, a new joint marketing organization for operating nuclear power plants in North America that will leverage the synergies between Westinghouse and Toshiba.

United States – Kuwait

In June 2010 the United States and Kuwait signed an agreement for cooperation in the area of nuclear safeguards and other non-proliferation topics. The agreement includes activities related to legislation, regulation, human resources development, radiation protection, waste management, reactor operation among others, but no plans for nuclear power plant construction.

United States – Persian Gulf Countries

American companies Lightbridge and Exelon Generation have signed an agreement with the Gulf Cooperation Council (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates) for a feasibility and siting study on a nuclear power station for electricity generation and water desalination in the region.

United States – France

1 - AREVA and NORTHROP GRUMMAN have signed an agreement for setting up a company -

Areva Newport News LLC – to fabricate heavy components (reactor vessels, cover, steam generator and pressurizer) for the French EPR reactor in the United States planned to start operation by 2011. AREVA expects to build up to 7 reactors in the U.S. over the next years and such strategy is meant to cope with a possible industrial bottleneck for heavy components, given the reduced number of heavy components manufacturers around the world.

2- AREVA also applied to the U.S. regulatory body – NRC for a license to build and operate a gas centrifuge uranium enrichment plant (Eagle Rock) near Idaho Falls. According to the company, this is about a multi-billionaire investment.

3- Areva will be the major supplier of engineering and construction services, and fuel for TVA's Bellesource-1 plant located in the American state of Alabama. THE contract amount is one (1) billion dollars and covers, among other activities, the nuclear island, a control room, digital instrumentation, training simulator and the fuel.

United States – Italy

The United States and Italy signed in September 2010, an agreement for civil nuclear cooperation, with a 5 years' duration (up to 2015), whereby Italy opens the doors to U.S. suppliers of nuclear technology and services.

United States – Czech Republic

In September 2011, the United States through its Department of Energy (DoE), American universities and the Czech Republic (several universities and research centers) have signed a cooperation agreements for research, contemplating the exchange of experiences and professional staff for generation IV molten salt-cooled power reactors.

United States – South Africa

In September 2009 the U.S. secretary of energy Steven Chu and South Africa's minister of energy signed a bilateral cooperation agreement for nuclear energy research and development, with emphasis on advanced reactor technology and nuclear systems. According to the American officer, the agreement reiterates its government position that nuclear energy has a major role in the world's energy future, mainly with respect to climate change challenges.

United States – Vietnam

In March 2010 a memorandum of understanding was signed to the effect of increasing the cooperation with the United States. This will give Vietnam access to nuclear fuel the country is expected to require in the near future, after the construction of the its first power reactor.

Russia and Others:

Russia – United States

Russia's nuclear fuel producer TENEX-Techsnabexport has announced the U.S. Department of Commerce's approval of the deal to supply enriched uranium for the Constellation Energy Nuclear

Group, in the period 2015 - 2025. This is Tenex's sixth fuel supply agreement on the American nuclear electricity generation market. The others were with Exelon and Fuelco (that represents Pacific Energy Fuels, Union Electric or AmerenUE) and Luminant.

Russia - Australia

In November 2010, Australia's prime minister Julia Gillard and Russian president Dmitry Medvedev signed an agreement to supply of uranium for Russian reactors.

Russia – United Kingdom

Through director Sergei Kiriyenko, Rosatom signed a nuclear energy cooperation agreement with British company Rolls-Royce.

Russia – Japan

Toshiba and Technabexport – Tenex has signed a commercial cooperation agreement for fabrication and supply of products and services relating to the nuclear fuel cycle, including uranium enrichment. One of the agreement's major objectives is to ensure a stable, secure supply of nuclear products and services. In the wake of this deal, a long-term supply agreement was signed whereby company Chubu Electric will receive nuclear fuel for 10 years. At present, Tenex supplies around 15% of Japan's demand for nuclear fuel and the agreement just signed is expected to increase this business.

Russia – China

Russia and China have signed a cooperation agreement for construction of 800-MW demonstration fast breeder reactors, which also includes the construction of Beloyarsk-4 reactors in Russia and Tianwan units 3 and 4 in China. Previous agreements contemplated the construction of Tianwan 1 and 2, three modules of a uranium enrichment plant and an experimental fast breeder reactor - CEFR

Russia – Netherlands

Russian Rosatom and Dutch Royal Philips Electronics signed in June 2011 an agreement under which imaging medical equipment for cancer diagnosis will be manufactured.

Russia – Bulgaria

Bulgaria's NEK - National Electric Company and Russia's Atomstroyexport have signed a contract for design, construction and commissioning of Belene nuclear power station's units (2x 1000 MW – VVER). Subcontractor 'CARSIB' (Areva NP-Siemens Consortium for Belene) will supply electric systems and instrumentation and control (I&C systems). Bulgaria also maintains a contract (in the amount of 2.6 million euros) for site selection and design of a near-surface national storage facility for low- and intermediate-level radioactive wastes in the country.

Russia – Nigeria

Russian government-owned Rosatom have signed a memorandum on nuclear cooperation with Nigeria's regulator to promote the peaceful use of nuclear energy in Nigeria.

Russia – India

India has signed a contract with TVEL, Russian manufacturer of nuclear fuel. The fuel will go to a number of Indian nuclear power plants, this being the first supply contract after the lifting of the bans imposed by the Nuclear Supplier Group (NSG) which prevailed up to 2008. Also, another signed agreement provides for the supply of 4 additional reactors in the Kudankulam area, where an installed plant already exists. The agreement expands the existing cooperation in the area of fuels, and nuclear technology, services and research.

Russia – Italy

An agreement has been signed for Italian participation in the construction of Russian technology 3rd generation nuclear reactors and in the study, design and construction of a prototype 4th generation reactor. Such deal will help Italy train specialized manpower.

Russia – UAE (Emirates)

The agreement with Russia is to share technology, equipment and nuclear material. Under the agreement Russia will legally be able to supply uranium as well as conversion and enrichment services to the UAE. The agreement allows cooperation in all fields of nuclear power, from uranium mining, fuel fabrication, equipment and research, construction of nuclear power plants – the whole cycle of civil nuclear power".

Russia – Oman

Russia and Oman have signed an intergovernmental agreement for cooperation in the peaceful use of nuclear energy with emphasis on infrastructures, research and development, as well as construction and operation of nuclear power plants. Agreement related work will be under the responsibility of Russian state-owned ROSATOM.

Russia – Jordan

Russia and Jordan have signed an intergovernmental agreement, with a 10 years' duration, for cooperation in the peaceful use of nuclear energy, covering a wide range of activities, such as engineering and construction, fabrication of components, safety studies, radiation protection and control, desalination, uranium mining, services, research among others.

Russia – Egypt

Sergei Kiriyenko, director general of ROSATOM said that the nuclear energy cooperation agreement, signed with Egypt is focused mainly on uranium prospecting and mining in that country. Other work groups will be set up for the construction of nuclear power plants, and training of specialized personnel in nuclear operation and regulatory activities will be provided. Egypt has 2 research reactors.

Russia – Slovakia

Russian company TVEL has signed a long-term nuclear fuel supply contract with a company Slovenské Elektrárne, plant owner and operator, to supply fuel for Mochovce units 3 and 4 (VVER-440). Contract activities covering 5 reloads and associated services are planned to start by 2012, when the plants are scheduled to come into operation. Italian ENEL is the owner's majority partner.

Russia – Turkey

Russia (Russian Technical Supervisory Authority - Rostechnadzor) and Turkey (Turkish Atomic Energy Agency -TAEK) have signed a cooperation agreement contemplating transfer of know-how and information in nuclear licensing, radiation protection and quality management.

Russia – Ukraine

1- Russia and Ukraine signed an intergovernmental agreement intended to resume the construction of Ukraine's two reactors at Khmelnitsky. The agreement was signed in Kiev by the minister of energy and fuel, Yuri Boyko and the director general of Russia's Rosatom, Sergei Kiriyenko and includes financing, design, construction, commissioning, services and supply for Khmelnitsky station's units 3 and 4.
2- Russian TVEL and Ukrainian Nuclear Fuel have signed an agreement for construction of a plant to manufacture nuclear fuel assemblies for VVER-1000 reactors in Ukraine (TVEL will assist in project financing).

Kazakhstan and others

Kazakhstan has no nuclear power plant, but it is the world's largest uranium producer, ahead of Canada and Australia, since December 2009. Kazatomprom - national nuclear corporation has 21 mines in operation in Kazakhstan and will be strategically involved in the construction of nuclear power plants in China as a means to diversify its business, currently dominated by mining.

The agreement signed with China Guangdong Nuclear Power Group (CGNPG) and China National Nuclear Corp (CNNC), will set up a company with Kazatomprom holding 51%, which will build plants in China and develop uranium mines on Kazakhstan's Irkol deposit in the Kyzylordinskaya region, whose annual production capacity is estimated at 750 tonnes of U_3O_8; on Semizbay deposits in Akmolinskaya (annual production capacity estimated at 500 tonnes of U_3O_8) and on Zhalpak deposits, annual production capacity estimated at 750 tones of U_3O_8. The agreements contemplate the supply of natural uranium to China for 10 years.

Similarly, agreements have also been signed with Canada (company Cameco) for access to UF_6 conversion technology (uranium hexafluoride) through a legal entity, ULBA Conversion LLP, to be built in Kazakhstan by Canada and expected to produce up to 12,000 metric tons of UF_6.
With France (AREVA) the signed agreements will allow nuclear fuel production (nuclear fuel assemblies) in the same plant of ULBA, with the fabrication of up to 1,200 metric tons of fuel rods and assemblies, with engineering and technology developed by AREVA. In addition, a cooperation agreement has also been signed with Belgium for experience exchange in the conduct of a civil nuclear program.

A supply agreement was signed in March 2010 where Japan expects to ensure steady supply of nuclear fuel for its nuclear plants. Under another agreement in September 2010, three Japanese companies signed a memorandum of understanding with Kazakh National Nuclear Centre, for a feasibility study on the construction of Kazakhstan's first nuclear plant.

Canada – India

Canada, through company CAMECO has set up a business Office in the city of Hyderabad, for the purpose of supporting and developing the company's business opportunities on the Indian nuclear fuel market and represent the company before the Indian government. Canada and India have concluded administrative arrangements to implement the nuclear cooperation agreement the two countries signed in 2010, Canadian Prime Minister Stephen Harper said in a statement on his official website November 6, following talks in New Delhi with Indian Prime Minister Manmohan Singh.

The nuclear cooperation agreement will allow Canadian firms to export and import controlled nuclear material equipment and technology to and from India to facilities under safeguards applied by the IAEA. - "India represents a huge business opportunity for Cameco and the entire Canadian nuclear energy industry," Cameco President and CEO Tim Gitzel said in Cameco's statement. "The ability to supply Canadian uranium to this rapidly expanding market will mean more jobs, more investment and more development here in Canada. It will also enable India to meet its growing electricity needs with a clean, carbon-free energy source," he said.

Canada – Vietnam

Vietnamese company Atomic Energy Institute has signed an agreement with Canadian NWT Uranium Corporation – Toronto intended to assess the region's physical and economic potential in uranium ore deposits, and assist in developing the country's nuclear industry.

Canada – Australia

Australia-based mining company BHP Billiton has signed an agreement to sell its Yeelirrie uranium deposit in Western Australia to Canadian uranium producer Cameco Corporation. It is one of Australia's largest undeveloped uranium deposits. The estimate indicates that Yeelirrie hosts measured and indicated mineral resources of approximately 139 million pounds of U_3O_8.

Canada – United Arab Emirates

Canada has signed a nuclear cooperation agreement with the United Arab Emirates to provide equipment, services and uranium, the Canadian Ministry of Foreign Affairs has announced.

Canada's foreign minister John Baird said that the agreement "allows Canadian companies to offer the full range of their equipment, services and uranium supply to the UAE's civilian nuclear market".

China and others

China – South Africa

In March 2009, China and South Africa signed a cooperation agreement concerning the development of high temperature reactors, for which both countries have research projects in progress. Participants in the agreement include South Africa's Pebble Bed Modular Reactor Ltd (PBMR), Tsinghua University's Institute of Nuclear and New Energy Technology (INET), and

China's Technology Company Chinergy Ltd.

China – Saudi Arabia

The deal, signed on 15 January 2012, sets a legal framework that strengthens scientific, technological and economic cooperation between Riyadh and Beijing, according to a joint statement. It calls for cooperation in areas such as the maintenance and development of nuclear power plants and research reactors, manufacturing and supply of nuclear fuel elements.

China – Argentina

1 - Signed in June 2012 agreement between China (Prime Minister Wen Jiabao) and Argentina (President Cristina Kirchner) including extensive cooperation on nuclear energy.
2 - In September 2012 the Argentine Planning Minister De Vido signed a new cooperation agreement which aims to transfer technology to developing reactors with enriched uranium for use in nuclear power plants near the country.

China – Belgium

The prime ministers of Belgium (Yves Leterme) and China (Wen Jiabao) have signed an agreement defining details for the construction of a pilot plant for production of MOX (mixed uranium oxide and plutonium fuel) to be used on Chinese plants. The agreement also contemplates technology transfer, technical assistance and participation in Belgium's MYRRHA Project (Multipurpose Hybrid Research Reactor for High-tech Applications).

China – Taiwan

A cooperation agreement has been signed for exchange of nuclear experience in such areas as radiation monitoring, emergency responses and operation of nuclear power plants. Since Taiwan holds no membership in the UNO, inspections by the IAEA are very limited.

China – Pakistan

Signed in August 2013 contract for supplying two new for the Karachi Coastal Nuclear Power Project in Pakistan which comprising two ACP1000 units

China – Canada

1- Agreement for development of advanced fuel design signed between Atomic Energy of Canada Ltd (AECL), Third Qinshan Nuclear Power Company (TQNPC), China North Nuclear Fuel Corporation and Nuclear Power Institute of China for use of the spent fuel from China's reactors on CANDU reactors in Canada and in China. The agreement also includes the use of thorium as a fuel.
2- CAMECO (Canadian uranium giant) has signed a supply agreement with Chinnuclear energy Industry Corporation (CNEIC) for around 10 tonnes of uranium concentrate up to 2020. The company is also negotiating a long-duration agreement with China Guangdong Nuclear Power (CGNP)
3- CAMECO signed a long-duration supply agreement with China Guangdong Nuclear Power Holding Co (CGNPC). The deal will ensure supply for the Chinese company whose nuclear fleet is growing at a steady pace.

China – France

1- Agreement between AREVA (45%) and China Guandong Nuclear Power Company – CGNPC (55%) for setting up a joint venture intended to compete anywhere in the world for nuclear construction projects by offering French (EPR) and Chinese (CPR1000) reactor models.
2- Another agreement has to do with UraMin, a company owned by AREVA to which Chinese investors would allocate capital, ensuring an interest of 49% in the company's equity, and subsequent Chinese access to UraMin produced uranium. In this process, UraMin will hold a captive market in China, where as France, guaranteed return on investments.
3- A third agreement, in November 2010, concerns a contract for 3.5 billion dollars covering a 10 years' supply of 20,000 metric tonnes of uranium for China Guandong Nuclear Power Company.
4- Under the fourth agreement, AREVA and China National Nuclear Corp.- CNNC set up a joint venture (CAST) for production and marketing of zirconium tubes for fabrication of fuel assemblies as early as 2012.
5- The fifth agreement deals with industrial cooperation in the field of spent-fuel treatment and recycling.

France and others

France – Brazil

1- France, through AREVA, has signed with Brazil a memorandum of understanding on industrial cooperation aimed at expanding Brazil's fleet of nuclear power plants and the fabrication of nuclear fuel for new plants to be built.
The focus will be on the nuclear program's major components, such as administrative, legal, and contractual framework; technical excellence; and financial and economic aspects, besides information exchange on the nuclear fuel cycle; procurement and supplier management; nuclear power plant construction, commissioning and operation.
2- French group GDF Suez and Brazilian companies Eletrobrás and Eletronuclear have signed an agreement for cooperation in the nuclear area. Such cooperation "protocol" will be basically focused on "exchange of information and experience" in the nuclear field. According to Suez, efforts will also be centered on such issues as nuclear power plant operation, technology, ownership arrangements, construction site selection process, and development of human resources.

France – Chile

In February 2011 a nuclear cooperation agreement was signed between Chile (Comision Chilena de Energía Nuclear - CCHEN) and France (Commissariat à l'*énergie atomique et aux énergies alternatives* - CEA) focused on nuclear training for Chilean scientists and professionals including design, construction and operation of nuclear power plants.

France – Congo

A France, through AREVA, has signed an agreement with Congo for uranium mining in that country.

France – Czech Republica

1- The French supplier Areva and several Czech companies signed in Prague cooperation agreement as part of the qualification of the French supplier for the construction of future EPR reactors, including reactor Czech Temelin planned-3 and -4. The Czech companies are ABB, Abegu, Spol Arako, Baest Machines and Structures, Excon Steel, I & C Energo, Kralovopolska RIA, Mandik, Metra Blansko, Modrany Energy, Schneider Electric CZ, Sigma Group, and Vitkovice Machinery Group and ZVVZ Engineering.
2- Czech power utility (CEZ) and AREVA signed a major 15-year uranium enrichment services contract for the Temelin nuclear power plant (units 1 and 2).

France – India

A France, through AREVA, signed with India - Nuclear Power Corporation of India Ltd (NPCIL) a long-duration contract for supply of nuclear fuel destined for plants operating under IAEA's control. The agreement also includes the possibility of developing and supplying India with new EPR reactors and the associated fuel.

A proposal to supply 2 EPR 1600MW reactors for the Jaitapur site in the State of Maharashtra, south of Mumbai, was submitted to the NPCIL in July 2009, the coming into operation of the units being planned for 2017 and 2018, respectively.

In parallel, AREVA has started strategic negotiations on two deals: one with Indian company Bharat Forge to create a joint venture for a forged parts manufacturing plant in India; and the other, with engineering company TCE Consulting Engineers Limited, a subsidiary of Tata Sons Ltd., for supply of general engineering services in India.

France – Japan

1- AREVA has signed an agreement to supply mixed oxide fuel – MOX (uranium + Plutonium) for Japanese Shimane plant owned by company Chugoku Electric Power Co.
2- Mitsubishi Nuclear Fuel Co and AREVA established a company in the United States (U.S. Nuclear Fuel) to produce fuel for advanced advanced pressurized water reactors, which Mitsubishi Heavy Industries is planning to supply for the U.S. market this decade. The new company will be located in AREVA's plant in Richland, Washington State.
3-French and Japanese companies have signed agreements that will see them cooperating on the rehabilitation of the Fukushima nuclear site and the start of commercial operations at the Rokkasho used fuel reprocessing facility.

France – Kuwait

Kuwait's sovereign wealth fund and France's government will invest in AREVA's capital increase. The Kuwait Investment Authority (KIA) offered 600 million euros for 4.8% of AREVA's shares and the French economy minister said that France will offer 300 million euros.

France – Morocco

France has signed a cooperation agreement with Morocco contemplating civil development of nuclear energy for peaceful purposes. Morocco has no energy sources in its territory other than uranium ore minerals.

France – Poland

In October, 2012 French companies Areva and EDF have signed a tripartite memorandum of understanding with Polish energy engineering company Energoprojekt as part of efforts to develop Poland's civilian nuclear power program.

France – Russia

In June 2010 companies EdF and Rosatom signed an agreement for cooperation in fuel research and development, and nuclear power plant construction and operation, besides personnel training and exchange of experiences.

France – Spain

AREVA signed an agreement to take effect in 2010 to supply nuclear fuel for Spain's Trillo nuclear power plant located in the State of Guadalajara. The agreement, with 6 years' duration, covers a number of different services.

France – UAE

The Emirates Nuclear Energy Corporation (ENEC) has awarded a contract worth more than 400 million euros (490 million US dollars) to Areva, to supply enriched uranium for the first power station under construction in the United Arab Emirates (UAE).

Europe – Bulgaria

Westinghouse Europe (now owned by Japanese Toshiba) and Bulgaria's Energy Holding EAD (BEH) have signed an agreement for civil nuclear cooperation, including technical support for plants in operation, lifetime extension, instrumentation and control and decommissioning.

Sweden – Arab Emirates

Swedish company Alfa Laval has been awarded a contract to supply heat exchangers for Arab Emirates' nuclear power plant at Brakka. The contract amount is 9.5 million dollars.

Jordan - Argentina

Argentina and Jordan have signed an intergovernmental agreement for cooperation in the peaceful use of nuclear energy, covering research activities and nuclear applications, production of radioisotopes, mineral exploration, construction and operation of power and research reactors, fabrication of components and processing of nuclear wastes.

Jordan – Japan

Japan and Jordan have signed a cooperation agreement with a 5 years' duration, whereby Japan will provide Jordan with support in developing the peaceful use of nuclear energy. Technology, training programs and infrastructures are among the major points of the agreement.

Jordan – South Korea

A consortium led by South Korea through the Korea Atomic Energy Research Institute (KAERI), has been awarded a contract to build a 5 MW research reactor in Jordan. A radioisotope plant and annexes will be set up in connection with the contract over the next five years.

Jordan – Turkey

A nuclear cooperation agreement has been signed Jordan and Turkey covering such areas as nuclear power plant operation, services, fuel supply, uranium exploration and radiation protection. Jordan has signed a similar agreement with 11 other nations.

United Kingdom – Jordan

Britain's foreign secretary David Miliband has signed a nuclear cooperation agreement with Jordan (Nasser Judeh). Durante the event, the secretary commended the transparent position of Jordan with respect to nuclear energy and reiterated his country's commitment to the development of civil nuclear programs in Arab countries.

Argentina – Canada

1-Argentina and Canada have signed an agreement for expanding the existing cooperation arrangements concerning the CANDU-6 reactor and development of the Advanced Candu Reactor (ACR-1000). A similar agreement exists with China.
2- Contracts have been signed between Nucleoelectrica and SNC-Lavalin for extending Embalse plant's useful life by 30 years. Technology transfer, industrial development and plant's power upgrade are also contemplated.

Argentina – Saudi Arabia

Argentina, through its Minister Julio de Vido, and Saudi Arabia have signed a cooperation agreement for the construction and operation of research and electricity generation nuclear reactors. The agreement contemplates such activities as safety, response to emergencies, waste management and treatment, and use of nuclear technology in industry, medicine and agriculture.

Argentina – South Korea

Argentina, through its Minister Julio de Vido, signed on September 16, 2010 a memorandum of cooperation with South Korea (Minister of Economy Choi Kyoung-hwan), aimed at new nuclear projects and extending the existing plants' lifetime.

Argentina - Turkey

Argentina's National Atomic Energy Commission - CNEA and Turkey's counterpart TAEK, signed an agreement (January 2011) for nuclear cooperation. TAEK's interest is domestic production of radioisotopes and the Argentinean designed nuclear power reactor (CAREM).

Brazil – European Union

The Brazilian government closed an agreement with the European Atomic Energy Community

(EURATOM) for research in the area of nuclear fusion which will include exchange of scientific and technical information, exchange of scientists and engineers, organization of seminars and conduct of studies and projects.

South Korea – Czech Republic

South Korea's company Doosan Heavy Industries & Construction has informed an agreement has been signed to buy Czech heavy equipment manufacturer SKODA Power, a deal that will give it the rights on Skoda's steam turbine technology. The agreement is estimated at 450 million euros and will enable Doosan to expand its business opportunities and thereby become a full-fledged power plant equipment supplier.

South Korea – Egypt

Egypt has formally requested assistance from South Korea to train technicians and engineers in the nuclear area, according to the International Cooperation Agency (KOICA), and activities are expected to begin still this year. This agency is experienced in technical training activities, having already worked jointly with the IAEA in training 400 nuclear engineers from Vietnam, Indonesia and Nigeria.

Japan – Poland

An agreement has been signed between companies GE Hitachi Nuclear Energy (GEH) and Energoprojekt Warszawa, S.A. (EW) to jointly assess the possibility of a partnership in development of new nuclear power plants, including the provision of engineering, construction and erection services.

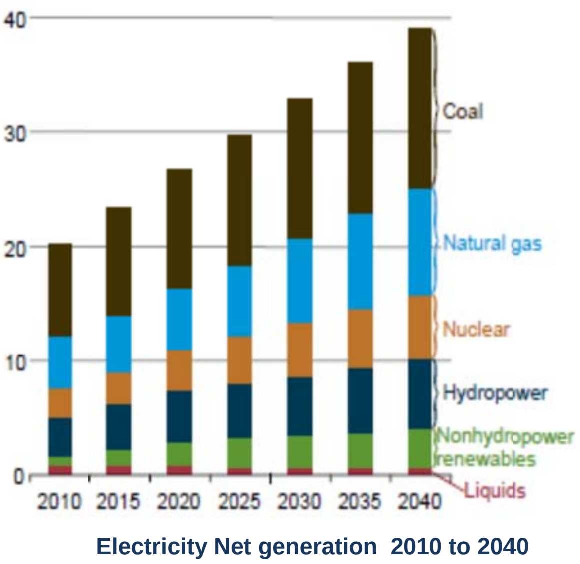
Australia – UAE

Australia has signed a nuclear co-operation agreement authorizing uranium exports to the United Arab Emirates, where construction started recently on the second of four planned nuclear power reactors. UAE to become Australia's first Middle Eastern export market for uranium and is "a step forward" for the UAE's plans for a domestic nuclear energy .

VI – Environment and Society

It is bewildering that in this twenty-first century, 20% of the world's population, around 1.4 billion persons, are still living without access to electricity. Another billion live with low quality power supply and/or with no assured power supply. Almost half of the world's population (2.7 billion individuals) is still dependent on biomass (vegetable coal) for cooking or heating. The UNO initiative to supply quality electricity for all people by 2030 (the so-called Sustainable Energy for All) is indispensable for achieving the millennium goal of eradicating extreme poverty, set by UNO itself, which will not be feasible if this issue remains unsolved.

Energy is the key to the planet and to mankind's way of living. It assures jobs, safety, food production, transportation and everything else. In the lack of it, the world's economies, countries, ecosystems, etc., do not work. Despite massive gains in global access to electricity over the last two decades, governments and development organizations must continue to invest in electrification to achieve critical health, environmental, and livelihood outcomes. The problems in developing countries may seem intractable: unsafe drinking water, subpar sanitation systems, limited access to electricity, low agricultural yields due to poor irrigation, environmentally unsustainable use of resources, and so on. For better solve these questions we can try to use more nuclear energy that is the most mature technology, lowest carbon-emitting technology available, being capable of generating large quantities of energy to supply the needs of society in quality, quantity and reliability.



Electricity Net generation 2010 to 2040
Source: EIA-US DoE (in trillions of kWh)

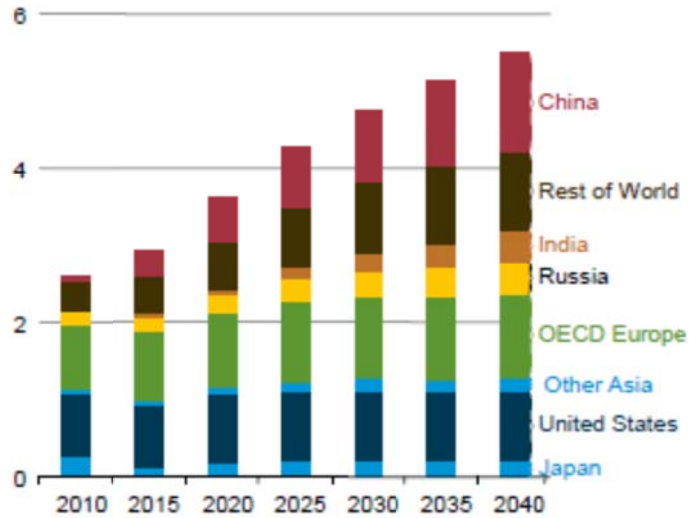
In 2009, around 70% of the non-pollutant energy generated in the United States came from nuclear power, with a share of only 20% of the total of electricity generated in the country. In general, the nuclear industry operates at a rate of 90% of its capacity, regardless of the season.

The shift in position of several environmental leaders on the nuclear issue, such as activist Patrick Moore and Stephen Tindale (ex-Greenpeace), James Lovelock (Gaia theory), Hugh Montefiore (Friends of the Earth), Stewart Brand (Whole Earth Catalog) shatters the myth associated with this subject, which is now addressed in a more technical, less dogmatic manner.

The environmentalists' opposition to nuclear energy has led to a billion extra tons of carbon dioxide - CO_2 directly pumped to the atmosphere, in as much as the energy new nuclear plants were prevented from generating has been supplied by fossil-fueled plants.

Energy independence is a factor of safety and wealth for countries; in this connection, nuclear energy, locally produced, free from greenhouse gas emissions, being a large size source and operating at the systems' basis, is a candidate for meeting such requirements.

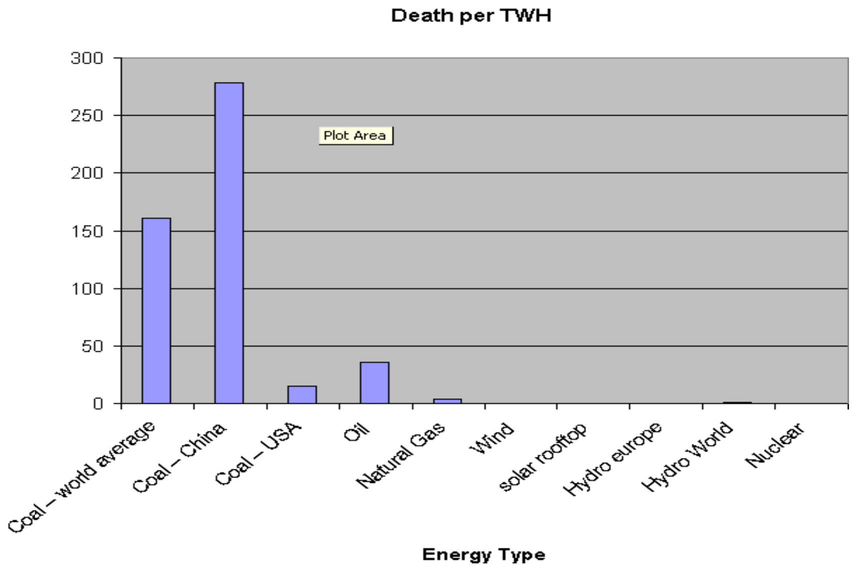
The availability and accessibility of energy, especially electric power, have become indispensable for modern society’s working conditions. Energy supply security is a concern for all governments, as it facilitates essential services for production, communication and commerce.



World net generation from nuclear by region until 2040 (IEA 2013-US DoE)

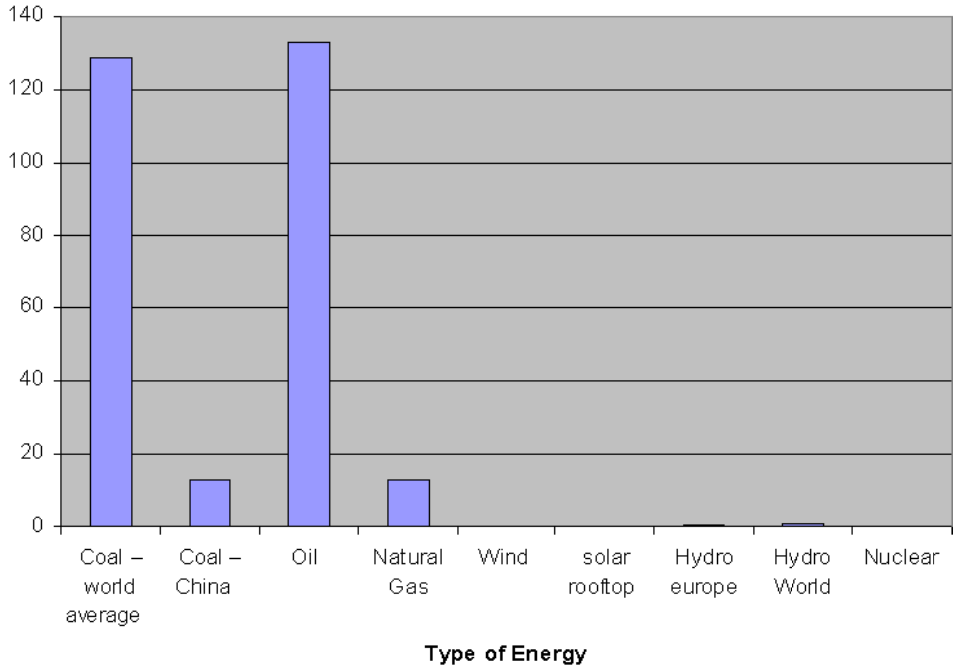
Energy supply security is intrinsically related to geopolitical preferences, technology strategies selected and the social policy orientations defined by the several countries. Combining the conditions associated with borders, neighborhood, continental location and domestic resources leads to the wide diversity of understanding of the energy security and sustainability concept.

The world's energy policy needs a significant revision for reasons that range from energy security to balance of payments and each country’s environmental concerns. Environmental disasters ensuing from the pursuit of fossil fuels whatever the cost bring a cost that today society will not and cannot afford any longer.



The implementation of a nuclear project always raises questions on the associated risks such as of radiation release under routine conditions and/or in case of accident; waste disposal and the issue of nuclear weapons proliferation. Such concerns necessitate appropriate treatment and society as a whole needs to be informed in a clear and simple language so that decisions are not taken out of sync with the will of the population, or under the effect of emotion. Avoiding conflicts is possible only when communication reaches **all in a** timely and effective manner.

Lifetime deaths per TWH



http://nextbigfuture.com/2011/03/deaths-per-twh-by-energy-source.html

Nuclear companies in the United States and Europe are being included in sustainability indexes of stock exchanges such as New York (Dow Jones Sustainability World Index - DJSI World). Such indicator represents a top international standard and any company listed on a stock exchange seeks to be included in the sustainability index due to its credibility and impartiality. Germany's EOn and RWE, Spain's Endesa and Iberdrola, United States' Entergy and Pacific Gas & Electric, Italy's ENEL and Finland's Fortum were nuclear companies included in 2009.

The heating up of the nuclear industry's labor Market attracts more university students to this technology and creates a virtuous circle, with more universities setting up courses in this area. This is the strategy defended by the IAEA in recent conferences on nuclear development, where special emphasis is placed on training and apprenticeship.

At present, there is a shortage of skilled labor in almost all activities, mainly in nuclear, which requires much qualification. Preparing trainers is also a goal of the IAEA which has offered courses for trainers, and more than 700 specialists have already attended.

The United States (DoE) have invested 17 million in fellowships for university researchers, for the specific purpose of developing-next generation power reactor technology, thus seeking to maintain a lead in this field. In addition, the Idaho National Laboratory (INL) is investing 50 million in the construction of a center dedicated to research and education in the nuclear area, which is part of the program to upgrade laboratory infrastructures.
The Fukushima accident is expected to somehow delay this entire worldwide process, but should not cancel it.

Another point to be considered is the program ***Megatons to Megawatts*** which, up to August 2011, eliminated the equivalent of a 17,000 nuclear warheads, through recycling of 500 million tons (MT) of highly enriched uranium (90%) which was converted into fuel for nuclear electricity generation plants.

During the 20 years since the program began, the Russians have dismantled thousands of weapons, and generated hundreds of millions of pounds of natural uranium equivalent in the form of 4% LEU (Low-Enriched Uranium), which has been delivered to electric utilities, mostly in the USA, for use in commercial nuclear reactors. For several years, the LEU deliveries have been equivalent to approximately 24 million pounds of mined uranium.

The program is expected to end in 2013. It will have a pressure over the international uranium supply.

VII – FUEL

Uranium

Yellowcake production – Photo INB

Uranium, a metal found in rock formations in the earth's crust, is extracted from the ore, purified and concentrated in the form of a yellow salt known as "yellowcake", raw material in the fuel cycle for production the energy generated in a nuclear reactor. Uranium is abundant in nature and there exist technologies capable of extracting material sufficient to meet up to 60 times the consumption needs. Mines produce around 60,000 tonnes a year, but part of the market is supplied by secondary sources such as the dismantling of nuclear weapons. The major use of the metal is in nuclear electricity generation.

Mining and uranium concentrate (U3O8) production constitute the first step of the fuel cycle, comprising ore extraction from nature (including the phases of prospecting and exploration) and beneficiation for transforming it into "yellowcake", or U_3O_8. It should be noted that this oxide serves all nuclear reactor technologies, being currently considered a "*commodity*".

Uranium-(photo INB)

For each MW installed in a light-water technology reactor "(LWR)", typically 178 kg/year of U3O8 are consumed.

Production from mines (tonnes U) - WNA								
Country	2005	2006	2007	2008	2009	2010	2011	2012
Kazakhstan	4357	5279	6637	8521	14020	17803	19451	21317
Canada	11628	9862	9476	9000	10173	9783	9145	8999
Australia	9516	7593	8611	8430	7982	5900	5983	6991
Niger (est)	3093	3434	3153	3032	3243	4198	4351	4667
Namibia	3147	3067	2879	4366	4626	4496	3258	4495
Russia	3431	3262	3413	3521	3564	3562	2993	2872
Uzbekistan	2300	2260	2320	2338	2429	2400	2500	2400
USA	1039	1672	1654	1430	1453	1660	1537	1596
China (est)	750	750	712	769	750	827	885	1500
Malawi					104	670	846	1101
Ukraine (est)	800	800	846	800	840	850	890	960
South Africa	674	534	539	655	563	583	582	465
India (est)	230	177	270	271	290	400	400	385
Brazil	110	190	299	330	345	148	265	231
Czech Republic	408	359	306	263	258	254	229	228
Romania (est)	90	90	77	77	75	77	77	90
Germany	94	65	41	0	0	8	51	50
Pakistan (est)	45	45	45	45	50	45	45	45
France	7	5	4	5	8	7	6	3
total world	**41 719**	**39 444**	**41 282**	**43 764**	**50 772**	**53 671**	**53 493**	**58 394**
tonnes U3O8	49 199	46 516	48 683	51 611	59 875	63 295	63 084	68 864
percentage of world demand*	65%	63%	64%	68%	78%	78%	85%	86%

The world's uranium resources can be divided into: reasonably assured and estimated additional resources. A "low-, intermediate- and high-cost" classification applies to those with exploitation costs: below 40 dollars/kgU, between 40 and 80 dollars/kgU, and above an 80 dollars/kgU, respectively.

In addition, the costs associated with the resource's classification are naturally continge nt on the production method involved. Around 60% of the world's uranium production comes from mines in Kazakhstan (36.5%), Canada (15%) and Australia (12%). Such production level had been declining since the 1990's due to the falling prices on the international market. Production has recently resumed growth and today it meets approximately 67% of the energy generation needs.

The already identified uranium sources are sufficient to supply 60 to 100 years' operation of the existing plants around the world and also to cope with the greater expansion scenarios projected for 2035 by the IAEA. Kazakhstan, having increased its production dramatically, became the world's greatest uranium producer at the end of 2009, when it reached the mark of 14,000 tons a year.

World production grew 9% in 2012, with Kazakhstan being again the biggest producer. In 2012 the greatest producing companies were Kazatomprom (Kazakhstan); Cameco (Canada), Areva (France), Rio Tinto (Australia) and Atomredmetzoloto (Russia). They all have business in all continents.

According to KazAtomProm (Kazakhstan's state-owned mining company) as the nuclear industry develops and uranium supply on the secondary market diminishes, the possibility arises of a nuclear fuel deficit on the market. Therefore, the company is getting prepared through a production increase and capacity upgrade planned to meet the peak of the demand forecast for 2016. The investments are of the order of 20 million dollars.

In contrast, Canada and Australia have cut back their productions, whereas Russia and Uzbekistan have kept theirs at steady levels. Uranium is mined in 20 countries, 7 of them (Australia, Canada, Kazakhstan, Namibia, Niger, Russia and Uzbekistan) accounting for 90% of the production.

At present around 68 thousand tons are used per year. This amount is sufficient to feed the current conventional reactors for 80 years. Taking into consideration the geologic bases known so far, prices are expected to increase if additional fuel is required for more reactors.

The 2008-2010 global financial crisis had an impact on uranium production, causing a production cutback in some mines. The uranium price dropped strongly due to the decline in demand. By 2013 the price drop was still sharp.

Such factors as falling prices, inflation associated with rising costs of production, smaller growth of

Known Recoverable Resources of Uranium 2011
Source: WNA

Country	Tonnes U	% World
Australia	1.661.000	31%
Kazakhstan	629.000	12%
Russia	487.200	9%
Canada	468.700	9%
Niger	421.000	8%
South Africa	279.100	5%
Brazil	276.700	5%
Namibia	261.000	5%
USA	207.400	4%
China	166.100	3%
Ukraine	119.600	2%
Uzbekistan	96.200	2%
Mongolia	55.700	1%
Jordan	33.800	1%
other	164.000	3%
World total	5.327.200	

mines' development and production, and more recently the accident that hit nuclear plants in Japan, have compelled some uranium producing companies to put their plants on downtime. Still, the coming into operation of new plants that are nearing completion of construction, and the possible recovery of the global economy are expected, in the medium term, to increase the demand for uranium on the international market.

WNA- 2012 - world's uranium mine production 8 largest-producing companies (82%)		
Company	**tonnes U**	**%**
KazAtomProm	8863	15
Areva	8641	15
Cameco	8437	14
ARMZ - Uranium One	7629	13
Rio Tinto	5435	9
BHP Billiton	3386	6
Paladin	3056	5
Navoi	2400	4
Other	10,548	18
Total	58394	100

According to consultant UxC, Asia should lead such capacity increase and overtake North America, currently the greatest consumer. The world consumption of U3O8 is expected to grow from 44.4 thousand tons to 110 thousand tons by 2030. A survey of the demand for the next 20 years indicates a critical need for a production increase, inasmuch the leading mines, over the past year, produced only 43.8 thousand tons of the ore.

In Brazil, state-owned Indústrias Nucleares do Brasil (INB) estimates that the reserves of the Santa Quitéria mine come to 142.5 thousand tons of uranium. The mine's full production capacity of 1.5 thousand tons of uranium concentrate per year will be reached in 2015, and the investment needed to render the project feasible are of the order of US$ 35 million.

The table below shows the expected uranium needs considering the reactors in operation, under construction, planned and proposed by each country as compiled by the World Nuclear Association - WNA until October 2013.

COUNTRY	NUCLEAR ELECTRICITY GENERATION 2012		REACTORS OPERABLE		REACTORS UNDER CONSTRUCTION		REACTORS PLANNED		REACTORS PROPOSED		URANIUM REQUIRED 2013
			Oct 2013		Oct 2013		Oct 2013		Oct 2013		
	billion kWh	% e	No.	MWe net	No.	MWe gross	No.	MWe gross	No.	MWe gross	tonnes U
Argentina	5.9	4.7	2	935	1	745	1	33	2	1400	212
Armenia	2.1	26.6	1	376	0	0	1	1060			86
Bangladesh	0	0	0	0	0	0	2	2000	0	0	0
Belarus	0	0	0	0	0	0	2	2400	2	2400	0
Belgium	38.5	51.0	7	5943	0	0	0	0	0	0	1017
Brazil	15.2	3.1	2	1901	1	1405	0	0	4	4000	321
Bulgaria	14.9	31.6	2	1906	0	0	1	950	0	0	317
Canada	89.1	15.3	19	13553	0	0	2	1500	3	3800	1764
Chile	0	0	0	0	0	0	0	0	4	4400	0
China	92.7	2.0	17	13842	30	32690	59	64420	118	122000	6711
Czech Republic	28.6	35.3	6	3766	0	0	2	2400	1	1200	574
Egypt	0	0	0	0	0	0	1	1000	1	1000	0
Finland	22.1	32.6	4	2741	1	1700	0	0	2	3000	1127
France	407.4	74.8	58	63130	1	1720	1	1720	1	1100	9320
Germany	94.1	16.1	9	12003	0	0	0	0	0	0	1889
Hungary	14.8	45.9	4	1880	0	0	0	0	2	2200	357
India	29.7	3.6	20	4385	7	5300	18	15100	39	45000	1326
Indonesia	0	0	0	0	0	0	2	2000	4	4000	0
Iran	1.3	0.6	1	915	0	0	1	1000	1	300	172
Israel	0	0	0	0	0	0	0	0	1	1200	0
Italy	0	0	0	0	0	0	0	0	10	17000	0
Japan	17.2	2.1	50	44396	3	3036	9	12947	3	4145	366
Jordan	0	0	0	0	0	0	1	1000			0
Kazakhstan	0	0	0	0	0	0	2	600	2	600	0
Korea DPR (North)	0	0	0	0	0	0	0	0	1	950	0
Korea RO (South)	143.5	30.4	23	20787	5	6870	6	8730	0	0	4218
Lithuania	0	0	0	0	0	0	1	1350	0	0	0
Malaysia	0	0	0	0	0	0	0	0	2	2000	0
Mexico	8.4	4.7	2	1600	0	0	0	0	2	2000	270
Netherlands	3.7	4.4	1	485	0	0	0	0	1	1000	103
Pakistan	5.3	5.3	3	725	2	680	0	0	2	2000	117
Poland	0	0	0	0	0	0	6	6000	0	0	0
Romania	10.6	19.4	2	1310	0	0	2	1310	1	655	177
Russia	166.3	17.8	33	24253	10	9160	28	29180	18	18236	5090
Saudi Arabia	0	0	0	0	0	0	0	0	16	17000	0
Slovakia	14.4	53.8	4	1816	2	942	0	0	1	1200	675
Slovenia	5.2	53.8	1	696	0	0	0	0	1	1000	137
South Africa	12.4	5.1	2	1830	0	0	0	0	6	9600	305
Spain	58.7	20.5	7	7002	0	0	0	0	0	0	1357
Sweden	61.5	38.1	10	9388	0	0	0	0	0	0	1505
Switzerland	24.4	35.9	5	3252	0	0	0	0	3	4000	521
Thailand	0	0	0	0	0	0	0	0	5	5000	0
Turkey	0	0	0	0	0	0	4	4800	4	4500	0
Ukraine	84.9	46.2	15	13168	0	0	2	1900	11	12000	2352
UAE	0	0	0	0	2	2800	2	2800	10	14400	0
United Kingdom	64.0	18.1	16	10038	0	0	4	6680	9	12000	1828
USA	770.7	19.0	100	98951	3	3618	9	10860	15	24000	19622
Vietnam	0	0	0	0	0	0	4	4000	6	6700	0
WORLD**	2346		432	371,9	70	73,366	173	187,74	314	356,99	64,978

Thorium

Thorium has a great potential as an alternative fuel to uranium. According to the director of the Institute of Nuclear Science at the University of Sydney, Reza Hashemi-Nezhad, thorium presents advantages vis-à-vis uranium because in the operation of a plant, it generates no plutonium or other materials that could be diverted to nuclear weapons, thus posing no risks of proliferation. Seeing that thorium usually is not a fissile material, it cannot be used in neutron flux thermal reactors, but it absorbs neutrons and transforms into a good fuel (uranium 233).

The accelerator-driven nuclear reactor- ADS, yet to be operational, could use thorium as a fuel and incinerate its own waste and also that of other uranium-fueled nuclear power plants.

Thorium is 4 times as abundant in nature as uranium, and the known deposits (mainly in Australia, India, USA, Brazil, etc.) could supply energy for thousands of years.

Only India has a thorium-based nuclear program, but the process does not use pure thorium. India expects to have a prototype thorium plant in operation by the end of the decade. Ratan Kumar Sinha, director of the Bhabha Atomic Research Centre in Mumbai, India, has informed that its staff is finalizing the construction site for a 300MW thorium-fueled power plant using an Advanced Heavy Water Reactor – AHWR, whose flexibility allows such fuel combinations as plutonium-thorium or uranium–thorium (low enrichment).

Plutonium-free generation can be a competitiveness factor, depending on what each country wishes in its nuclear program. Thorium's lagging development over decades is probably due to its unfitness to meet military ambitions. The generated nuclides are gamma radioactive, traceable and easily detectable, which would hinder their misuse (unlawful actions).

VIII – Spent Fuel, Radiation, Waste and Reprocessing

All human activity produces waste. No technology is absolutely safe or free from environmental impacts.

Spent Fuel

Conventional waste is what is left over - in solid, semi-solid and/or liquid state - from any activities or processes of an industrial, medical, commercial, agricultural or other origin, including slurries and ashes from pollution control or water treatment systems.

According to the IAEA, the annual discharge of spent fuel from all electricity generation reactors is 10,500 tonnes (of heavy metal).

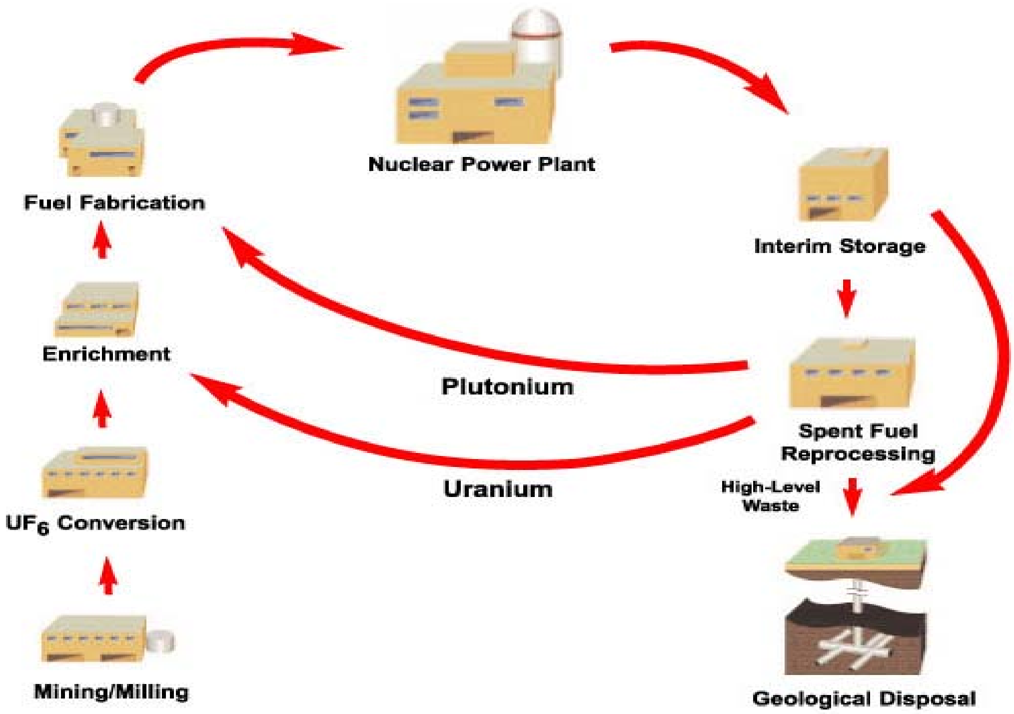
Some countries view spent fuel as a material to be stored in final repositories for high level radioactive waste. Other countries consider this material an energy resource to be reprocessed and reused.

Thus, there exist two waste management strategies being currently implemented in the world. The first
involves reprocessing or storage for future reprocessing, so as to extract the fuel (uranium and plutonium) still existing in the spent material. This will produce the MOX fuel (mixed uranium oxide and Plutonium) that will be used on specifically designed plants. Around 33% of the world's spent fuel discharges have been reprocessed.

Usina de Reprocessamento Sellafield Cumbria – Inglaterra

Under the second strategy, the used fuel is considered waste and preliminarily stored until its final disposal. The 50 years' experience with handling this material has proven safe and efficient in both technologies that have been used so far - Wet and Dry storage technologies. In both cases, the spent fuel is first stored in the reactor's pool and subsequently in interim repositories that can be located in the nuclear power plant itself.
Today, the countries reprocessing nuclear fuel are China, France, India, Japan, Russia and the United Kingdom. Those that store for possible future reprocessing are Canada, Finland and Sweden.

The United States have yet to fully define the technology to be used. Most other countries have not even defined the strategy and are storing their used fuel used pending the further development of the technologies associated with both strategies.



Nuclear Fuel cycle

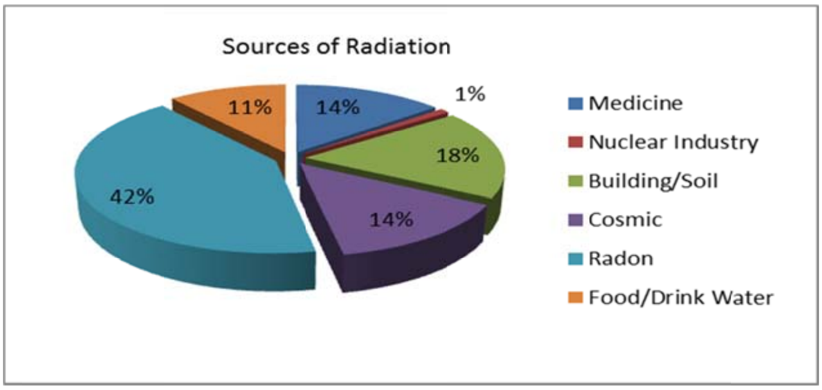
In 2006, around 180 tons of MOx were used on two BWR reactors and on 30 PWR reactors in several countries (Belgium, France, Switzerland, Germany, etc.). An expanded use is expected in Japan and India from 2010 onwards.

Programs for spent-fuel final storage facilities are under way in several places, but none should be commercially operable prior to 2020. The fact that no final repository is currently in operation does not mean a solution for waste treatment has not been conceived. The treatment technology involving final disposal consists of isolating the material through shielding and vitrification and subsequently storing it in stable rock cavities, where the material will be contained until its radioactivity decays down to a level that brings no harm to human species or the environment.

The development of innovative solutions such as the Myrrha project (Multi-Purpose Hybrid Research Reactor for High-Tech Applications) in Belgium offers other possibilities for nuclear waste treatment such as transmutation. Although a large capacity plant is still a long way off, a pilot project (at a cost of 1 billion euros) is expected to be commissioned at the Belgian Nuclear Research Center - SCK by 2019, as part of the Myrrha project. The facility is to be tested for 5 years prior to the start of commercial operation, but is expected to provide a significant reduction in the quantity and size of the repositories for high activity wastes.

Radiation

As with many things in nature, radiation can be good or bad, depending on the amount. In our planet there exists a natural background radiation that all of us are exposed to every day. The human being is adapted to such sources. The sun, granite rocks, monazite sands and other naturally radioactive materials found in the air, in the sea and on land are part of such radiation. Background radiation varies a lot according to the regions of the world, depending on such factors as rock composition in the environment, altitude, etc.



Only 15% of emissions come from mankind activities (Medicine and nuclear industry)

The radiation produced by a nuclear reactor is similar to natural radiation, but at a more intense level, and for this reason, the reactor has the protective mechanisms necessary to isolate radiation from the environment and individuals. More than 85% of the radiation doses received by mankind come from nature.

Types of Radiation	Caracteristics and risks
ALFA	Does not penetrate the skin, only dangerous if ingested
BETA	can be blocked by wooden / aluminum, etc.. - Little danger
GAMA Ray	dangerous for people - must be isolated
Raio X	dangerous for people - must be isolated
COSMIC Radiation	Particles from space very dangerous. Our protection is the atmosphere
NEUTRONS	produced by nuclear fission, can cause harm to human beings - must be isolated

As the senses of human beings are unable to detect radiation, detection devices are needed for measuring such releases, whether they occur from natural sources or result from accidents. Every day each inhabitant on the planet receives a radioactive dose that varies according to the location and/or activity.

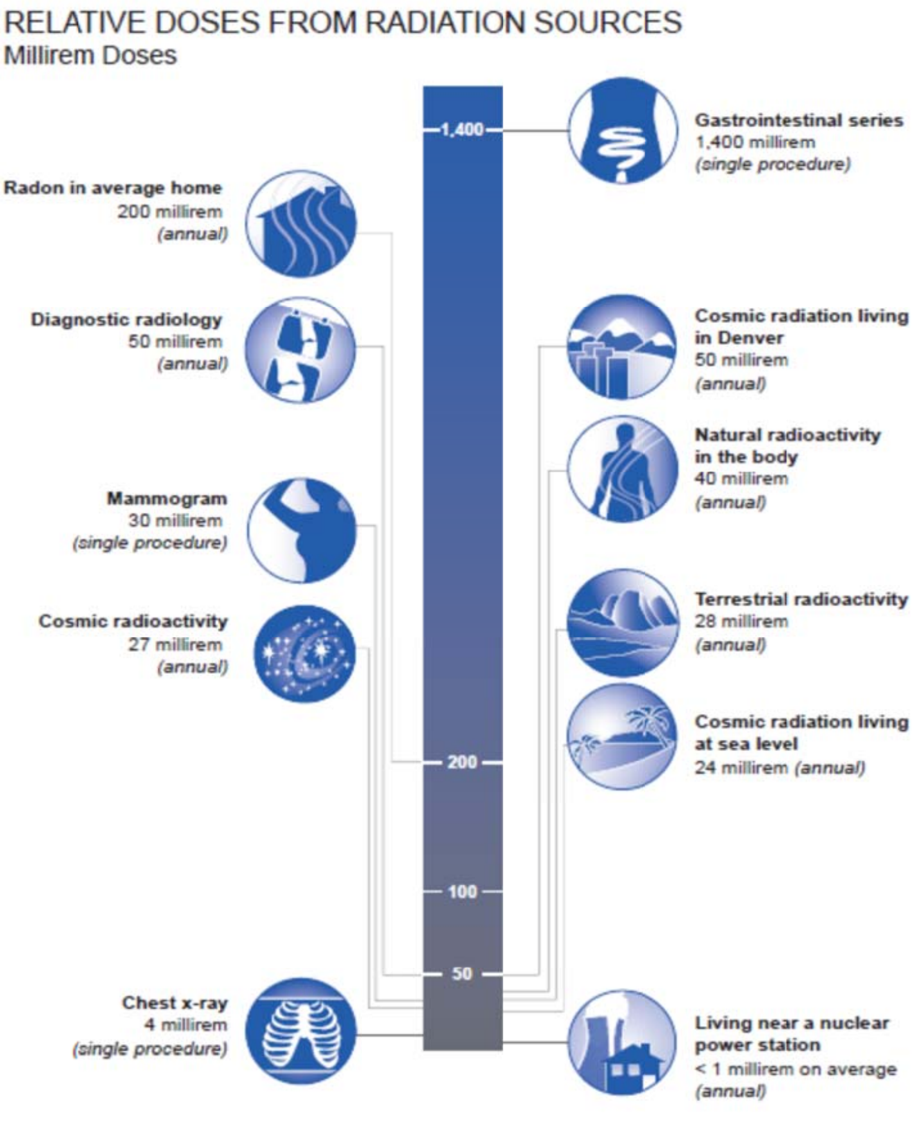
Routine medical procedures used by society add extra radiation doses to the human body. The table gives examples of radioactive dose by medical procedure performed.

Medical Procedure	Dose in mSv
Dental radiography	0,005
Mamography	2
Brain Scan	0,8 a 5
Breast Scan	6 a 18
Gastrintestinal X-Ray	14

The SI unit for radiation exposure is the Sievert (Sv) and its multiples, the milli Sievert – mSv (1 mSv = 0.001 Sv) and the micro Sievert - μSv = 0.000001 Sv).

This is the international unit that defines the standards for radiation protection, taking into account the biological effects of the different types of radiation.

The doses are cumulative when the source is constant:
μSv/h = 1 millionth of the Sievert per hour of exposure (0.000001 Sv/h)
Another unit used is the Rem, which is equal to 0.01 Sv.



From EPA – Radiations: Risks and Realities

Compared with other events that affect the health of individuals, radioactivity is one of the most extensively studied subjects and also one that has been mastered by science. In every country, protection standards are established in line with the recommendations of the ICRP - International Commission on Radiological Protection, which determines that any exposure should be as low as reasonably achievable - ALARA. The world's highest authority on effects of radiation on human health is the UNSCEAR - UN Scientific Committee on the Effects of Atomic Radiation, a United Nations' body dedicated to the subject.

The public's lack of knowledge on this subject and the large number of measurement units give rise to much confusion and disinformation, often purposeful, and can cause fear and anxiety in lay people.

Yearly Radioactive Dose	mSv/year
Maximum feasible dose for any human work	1
Acceptable dose to live near to NPP	0,0001 to 0,01
Acceptable dose to live close to the Coal Plant	0,0003
Dose to sleep next to someone else (8 hour/day)	0,02
Yearly dose from cosmic radiation	0,24
Yearly dose due to radiation from the Earth	0,28
Yearly dose of radiation in the human body	0,4
Yearly dose of radiation by atmospheric sources	2
Yearly average Dosefor Americans	6,2
Average dose on flights from New York to Tokyo	9
Yearly Average dose limit for nuclear workers	20
Dose of background radiation in parts of Iran, India and Europe	50
Radiation dose by smoking 30 cigarettes per day	60 to160

Radioactive contamination is the presence of radioactive material in any place where it is not desired, therefore, a radioactive material without any contention control. Cleaning up radioactive waste usually means scrubbing with soap and water, pails and brushes, a messy process that is dangerous for those exposed to dust and contaminated wastewater.

Almost everything in the world normally emits radiation. The radioactivity of a radiation emitting material needs to be measured in order to define the protection criteria. In this case, physics defines the Becquerel (Bq), the unit representing the number of decays per second in the material considered.

Radiation exposure is cumulative; it can be measured in µSv/h, varies a lot, and is known in most cases. Below are a few examples of radiation dose per hour of exposure in µSv/h:

Measured average dose of radiation	µSv/h
Average individual from background radiation	0,230
Average individual from background radiation for Americanos	0,340
Average individual from background radiation for Australians	0,170
Average dose in Fukushima on 25/05/2011	1,600
Average dose in Tokyo on 25/05/2011	0,062

In Brazil, in the locality of Guarapari, Espírito Santo, a dose of 200mSv/year is normal due to monazite sands on beaches.
Examples of radiation doses per year of continuous exposure:

Radioatividade em alguns materiais naturais ou não	
Fonte: WNA	
1 adulto humano (65 Bq/kg)	4.500 Bq
1 kgde café	1.000 Bq
1 kg fertilizante superfosfatado	5.000 Bq
O ar de uma casa de 100 m^2 na Austrália (randon)	3.000 Bq
O ar de uma casa de 100 m^2 na Europa (radon)	até 30.000 Bq
1 detector de fumaça (com amerício)	30.000 Bq
Radioisótopos para diagnósticos médicos	70 milhões Bq
Fontes de Radioisótopos terapias médicas	100Trilhões Bq (100 TBq)
1 kg de resíduo nuclear (vitrificado) de alta atividade com 50 anos de idade	10 Trilhões Bq (= 10 TBq)
1 sinal luminoso de saída (anos 1970)	1 Trilhões Bq (1 TBq)
1 kg de urânio	25 milhões Bq
1 kg do minério de urano (Canadá, 15%)	25 milhões Bq
1 kg do minério de urano (Austrália, 0.3%)	500.000 Bq
1 kg de resíduo nuclear de baixa atividade	1 milhão Bq
1 kg de cinzas de carvão	2.000 Bq

Accidental radiation doses pose varying effects on the human being, given that the exposure is higher or more concentrated.

- Biological effects will not be felt until after an acute exposure of 250 mSv.
- Temporary effects such as nausea, vomit and diarrhea appear with an acute dose of 1000 mSv.
- With acute doses of 4,000 mSv the human being is severely affected, and approximately 50% will eventually die in a short timespan (about 1 month)
- Acute doses of 7,000 mSv are lethal for 100% of the individuals.

If the radiation comes from external sources, the skin and tissues near the body's surface are the least affected. Organs deep in the body are affected only by penetrate-gamma and neutron radiation. Still, if ingested, inhaled or introduced into the body through wounds, the radioactive material can be taken to the vicinity of critical organs and irradiate them in such internal position. The amount of radiation received from an external source can be controlled by simply keeping the source away.

Once the material has been inhaled and/or ingested, it continues to irradiate the body until it is eliminated naturally by the organism. Some radionuclides remain in the body for a long period of

time- months or even years. The biological effects of ingested radioactive material are identical to those produced by external radiation, since contamination emits radiation.
The internal location of the material emitting alpha and beta radiation allows these radiation to affect the organs and tissues, which would not normally occur due to their low capacity of penetration.

Radiation Facts

Even if you lived next door to a nuclear power plant, you'd still get less radiation each year than you'd get in just one flight from New York to Los Angeles.

About 85 percent of the radiation humans receive comes from natural sources such as cosmic rays from space, granite and even our food. The remainder of our annual radiation dose comes from artificial sources such as medical x-rays. Less than 0.1 percent comes from the nuclear industry.

Potassium Iodine – A protective measure not a magic pill

One of the protective measures that communities around nuclear power plants might use in the case of a radiological emergency is potassium iodine. But potassium iodine, often just called by its chemical symbol, KI, is not an "anti radiation" pill.

Potassium iodide is a salt, similar to table salt. Potassium iodide, if taken within the appropriate time and at the appropriate dosage prevents the thyroid gland from taking in radioactive iodine. This can help to reduce the risk from thyroid disease, including cancer as a result of a severe reactor accident. KI doesn't protect the thyroid gland from any other radioactive element nor does it protect the thyroid or the whole body from external exposure to radiation.

Nuclear and Radioactive Wastes

Nuclear waste management begins at the design phase and continues during the operation of any facility planned to use radioactive material, and takes into consideration the need to limit, as much as possible, the waste volume and the activity producing it. Waste identification, selection, treatment, packaging, transportation, interim storage and final storage are part of the management process, noting that each item must be properly treated. Safety conditions, radiation protection, traceability and volume reduction are the basis of nuclear waste management.

All radioactive wastes generated in nuclear power plants are to be stored in a safe manner and isolated from the public and the environment. Wastes are classified as high activity (spent fuel assemblies); intermediate activity wastes (purification resins and process fluids); and low activity wastes (consumables and discardable material used in operation and maintenance activities).

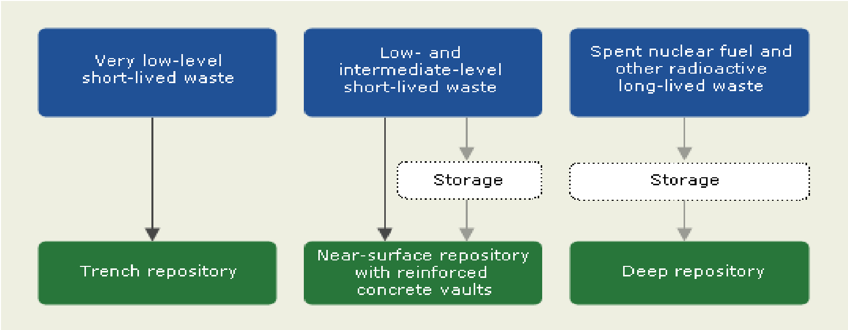
High-level wastes are stored, for the entire useful life of the plant, in pools located inside or outside the plant's building. Intermediate-level wastes are to be stored in appropriately designed buildings beside the plant, for the entire useful life of the plant. Low-level wastes are also stored in buildings located near the plant.

CNEN - National Nuclear Energy Commission, responsible for implementing Brazil's radioactive waste policy, is currently developing the following projects:

• **Repository for Low- and Intermediate- Level Wastes**
Purpose: To conceive, design, license, build, and commission a National Repository for Low- and Intermediate- Level Wastes.

• **Development of Containers for Spent Fuel Transportation and Storage**
Purpose: To define, develop, build and qualify a transportation container and a storage container for spent-fuel from nuclear power plants.

Radioactive wastes in liquid, gas or solid form are generated in different phases of the fuel cycle, showing a wide range of toxicity. The appropriate treatment, conditioning and storage is contingent on the material's level of activity (low, intermediate or high).



Low- and intermediate-level radioactive wastes from nuclear power plants consist in general of materials used in cleaning operations, replacement parts, clothing, shoe covers, and gloves used inside reactor buildings, impurities, filters, etc.

Such materials are packed into metal containers, tested and qualified by the regulatory body, and transferred to an interim storage facility, normally on the plant site. Such storage facility is permanently controlled and monitored by radiation protection technicians and nuclear safety specialists.

As to spent-fuel assemblies, which are considered high-level waste, they are placed in a pool inside the plants or in a long-term intermediate storage facility, in compliance with all internationally recognized safety requirements.

Until the fuel cycle is closed, through reprocessing, water-cooled reactors will continue producing high-level wastes that must be managed and stored for a long time span.

Inasmuch as such wastes are of a much smaller magnitude than the wastes from fossil-fueled power plants, *e.g.* based on coal, and since nuclear power plants in general provide ample space for waste storage during the plant's useful lifetime, there is no urgency in implementing a final solution for waste conditioning.

inal Storage for low and intermediate levels in World

This makes it possible to carefully develop plans and policies for closing of the nuclear fuel cycle, including final waste disposal.

Approaches to nuclear waste management - Selected countries			
Approache type / Country	**Spent Fuel in Storage (MTHM)**	**Centralized interim Storage**	**Expected date for operation of geologic wastw disposal site**
Deposição direta			
Belgium	2.699	yes	2040
Canada	40.054	no	2025
Finland	1.684	no	2020
South Korea	10.185	planning for 2016	unknown
Spain	3.827	planning for 2012	2050
Sweden	4.893	yes	2022
USA	62.400	no	unknown
Reprocessamento			
China	1.532	no	2050
France	12.400	no	2025
Germany	12.788	yes	2035
Japan	12.585	no	2035
Switzerland	1.040	yes	2040
United Kingdom	423	no	2025

source: EIA _US DoE 2011

Development of nuclear energy presupposes nuclear industry’s commitment to waste management.

IX- Proliferation and Risks for Safety - NPT

The Nuclear Non-Proliferation Treaty - NPT, concluded at international level, recognizes all involved Parties' right to develop and use nuclear energy for peaceful purposes.

The 189 signatories to the landmark 1970 arms control treaty – which is aimed at preventing the proliferation of nuclear weapons and urges those countries with atomic warheads to relinquish them – get together every five years to assess compliance with the terms of the pact and the progress made toward achieving its goals. The last review conference on the NPT was in May 2010 and the next will be held in April 2012 in Vienna.

More than two decades after the Cold War ended, the world's combined inventory of nuclear warheads remains at a very high level: more than 17,000. Of these, some 4,300 warheads are considered operational, of which about 1,800 US and Russian warheads are on high alert, ready for use on short notice.

Despite significant reductions in US, Russian, French and British nuclear forces compared with Cold War levels, all the nuclear weapon states continue to modernize their remaining nuclear forces and appear committed to retaining nuclear weapons for the indefinite future.

The exact number of nuclear weapons in each country's possession is a closely held national secret. Despite this limitation, however, publicly available information and occasional leaks make it possible to make best estimates about the size and composition of the national nuclear weapon stockpiles:

Status of World Nuclear Forces Early-2013*

Country	Operational Strategic	Operational Nonstrategic	Reserve/ Nondeployed	Military Stockpile	Total Inventory
Russia	1,800	0	2,700	4,5	8,500
United States	1,950	200	2,500	4,65	7,700
France	290	n.a.	?	300	300
China	0	?	180	250	250
United Kingdom	160	n.a.	65	225	225
Israel	0	n.a.	80	80	80
Pakistan	0	n.a.	100-120	100-120	100-120
India	0	n.a.	90-110	90-110	90-110
North Korea	0	n.a.	<10	<10	<10
Total:	~4,200	~200	~5,700	~10,200	~17,300

up date early 2013

All numbers are approximate estimates and further described in the Nuclear Notebook in the *Bulletin of the Atomic Scientists*, and the nuclear appendix in the SIPRI Yearbook.

The risk of proliferation associated with the use of nuclear energy essentially may come from two specific nuclear activities: enrichment of uranium and reprocessing of spent nuclear fuel. These activities require very complex and expensive technologies.

Nuclear fuel and materials on the nuclear and radiation industry's supply chain can be used in fabrication of nuclear weapons; for this reason they must be protected against theft, sabotage or accident. As a consequence, all use of nuclear material requires precautions and safeguards. This also applies to handling facilities (for example, an external event – an explosion – near an isotope separation plant can impair its functioning for decades and damage the public's trust, creating huge problems for general acceptance of this industry).

The treaty is considered unequal even by signatory countries, as is the case of Brazil, because it perpetuates the division into declared nuclear powers (nuclear-weapon states) and the remaining countries (non-nuclear-weapon states). Additionally, the great powers prioritize the non-proliferation agenda — and exercise strong pressure on the countries' right to develop the peaceful use of nuclear energy. Still, little is required of the declared nuclear powers in connection with disarmament.

Over the past recent years, the great powers achieved nothing concrete to the effect of cutting back and destroy their nuclear arsenals. On the contrary, in many cases what has been seen is an effort to modernize them and develop strategies where they reserve the right to use nuclear weapons against their enemies. That is the case of the United States with its nonproliferation strategy — a corollary that holds the United States has the right to use nuclear weapons against terrorist groups and countries that support them.

The consequence is a climate of deep insecurity and disquiet in the international setting, generating the necessity of dissuasion strategies for those countries that feel threatened.

An example of this was presented in 2011 at a seminar on the NPT held in Rio de Janeiro. The position of India, defended by its ambassador to Brazil - B.S. Prakash, was clear and emphatic in affirming that his country refuses to participate in the NPT because India considers it discriminatory and unfair. He defended that India, since its independence in 1948, has clearly affirmed, that given its dimensions, being one-fifth of the world's population, cannot forgo any source of energy, technology, or means of dissuasion that other countries similar to India have and will not relinquish. In his view, an international convention should be created to ban the use of nuclear weapons. Such proposal has been defended by several developing countries as a means to make the use of such weapons a crime against humanity, but it is rejected by developed countries.

Another point addressed during the seminar debates, was the U.S. proposal for "multilaterization of the uranium enrichment cycle". This is about setting up an international mechanism (similar to a bank) to enrich uranium for signatory countries of the treaty. Under such proposal, the interested country would hand over its uranium reserves to the bank, which would authorize another "accredited" country (one of the five nuclear powers) to carry out the enrichment. Subsequently, the uranium would be taken back to the country of origin, in small quantities, on the argument of preventing the possibility that a sufficient quantity of enriched uranium might exist for production of a nuclear weapon.

In the view of countries that hold reserves and technology, such proposal would allow much meddling in such a strategic resource. The world demand for sources of energy is great and has expanded with the dilemmas arising from global warming, which causes nuclear energy to be both a matter of commercial competition and a safety theme. In this respect, besides national security matters, the interest in maintaining the monopoly of fissile material trade seeks to avoid the possibility that other countries might participate on such markets. The great powers have exercised strong pressure on developing countries, such as Brazil, to have them sign additional protocols intended to further expand the restrictions on development of nuclear energy, and on the production and management of fissile materials.

Brazil has refused to sign such additional protocol and even prevented IAEA inspectors from performing inspections on a part of the program deemed to be a scientific secret. Moreover, Brazil in association with Argentina has an oversight agency that jointly controls the production of fissile material, the ABACC (Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials), and verifies the peaceful use of nuclear materials produced by both countries.

According to Samuel Pinheiro Guimarães, former minister of the Secretariat for Strategic Matters, under the Office of the President, Brazil’s acquiescence to signing an Additional Protocol to the Safeguards Agreement, an instrument of the Non-Proliferation Treaty (NPT), would enable inspectors from the International Atomic Energy Agency (IAEA), with no prior notice, to inspect any industry they might consider of interest besides the nuclear facilities. This includes ultracentrifuge plants and the nuclear powered submarine, providing access to any machine, its parts and methods of fabrication; that is, access to any place in the Brazilian territory, for inspection, including civil and military research institutions. Since the inspectors are formally officers of the IAEA, but in fact highly qualified technicians, and often national citizens from developed countries, naturally imbued with the "justice" of an existing nuclear oligopoly not only military, but also civil, they are always prepared to collaborate not only with the IAEA, which they do as a matter of professional duty, but also with the authorities and companies in their countries of origin.

X – Some Nuclear Applications

The nuclear field offers a number of applications, and just a few are mentioned below.

In the **medical field**, the highlights are conventional radiology, mammography, computerized tomography, panoramic dental radiography, digital angiography, PET exam (Positron Emission Tomography), etc.

The use of radiopharmaceuticals, which is a compound containing a radioisotope in its structure and can be used in both diagnosis and therapy, warrants special attention. The world's most extensively used radionuclide is Technetium-99, in around 75% of medical applications, totaling 50 million procedures a year.

Technetium-99m is produced by decay of Molybdenum-99. The current problems in supply of this radionuclide arise from its short useful lifetime, just 6 hours, which necessitates its generation near the center of use; and also from constraints in the supply chain, where production reactors around the world are old facilities (from 40 to 53 years of age), and few.

Also in the medical field, an important advance has been made jointly with the IAEA in African countries, to the effect of neutralizing one of the worst vectors of disease transmission.

The objective here was combating the Tsetse fly (transmission vector of the sleeping sickness in humans). The technique used in the process is the insect sterilization technique – SIT, a nuclear technology by which laboratory-sterilized male insects are let loose in thousands over infested wild areas. When sterilized males breed with fertile females of the area, these fail to lay eggs, thus contributing to eradicate the target harmful species. The process is widely used against other parasite insects infesting farm crops, and represents a means to interfere in natural selection through insect birth control.

Industry also has a variety of applications, with X-ray inspection of welds being one of the most applied techniques. Other uses are the irradiation of plastic materials (syringes, gloves, etc.) in the pharmaceutical industry for sterilization, and irradiation of plastics to increase their hardness in the automotive industry (fenders).

Around one fifth of the world's population, especially in Africa and Asia, has no access to potable water, and water **cleaning and sea water desalination** in such areas is a matter of sustainability for society. Desalination is energy intensive and in general uses fossil or nuclear energy sources. In this case, the use nuclear energy offers the advantage of avoiding the pollutants arising from other sources.

Ionizing radiation is used in **preservation and restoration of art works** to exterminate such plagues as termites. In Brazil, the IPEN has already treated paintings, xylographs, papers and sundry pieces infested by fungi, bacteria, termites and plant borers. This technology does not generate toxic or radioactive wastes.

Archaeology and history use irradiated material (carbon 14) for dating of pieces.

In the area of fuels, besides, of course, electricity generation in plants like those in Angra dos Reis, Brazil, nuclear energy is used in ship and submarine propulsion. In this connection, it is worth mentioning the plutonium-powered space probes Voyager I and II, launched in the decade of 1970 to remain in activity for 5 years. Today their systems are still working and transmitting information to control centers on earth.

TRIGA CNEN/CDTN - Belo Horizonte

Argonauta CNEN/IEN Rio de Janeiro

Food losses after harvest or slaughtering as a result of insect or microorganism infestation is estimated to be of the order of 25% to 50% of everything that is produced.

Irradiated Food and Label for the process

Product	Without Ionization	With Ionization
Garlic	4 months	10 months
rice	1 year	3 year
banana	15 days	45 days
potato	1 month	6 month
onion	2 months	6 months
flour	6 months	2 years
fish	5 days	30 days
chiken	7 days	31 days
vegetables	5 days	18 days
mango	7 days	21 days
corn	1 year	3 year
strawberry	3 days	21 days
papaya	7 days	21 days
wheat	1 year	3 year

Increase (Average) in lifetime of irradiated foods

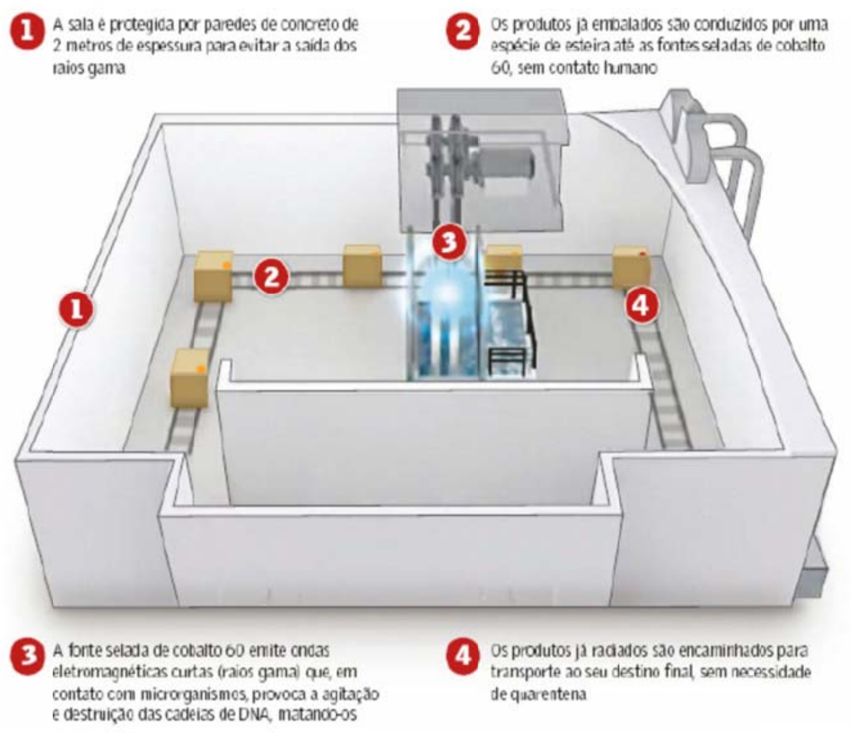
In agriculture its main use is in food irradiation, especially fruits and vegetables as a way to keep them as recommended by the WHO - World Health Organization processes vary by type of food, but the goals are to delay the ripening fruits increasing their shelf-life, elimination of various insects and microorganisms that cause spoilage of; destroy harmful bacteria and fungi, while avoiding or reducing risks for diseases and food poisoning.
The technique is also used in the conservation of fertilizers (peat) and reducing post-harvest or post-harvest due to infestation by insects or microorganisms making better the indicator of loss in agriculture which is estimated to be around 25% to 50% of what is produced. Nowadays, more than 50 countries (including Brazil regulations in this regard since 2001) approved the irradiation process for about 60 food products.

The main difficulty of the process is the negative marketing of irradiated products because they need to have a warning label on the packaging to inform the consumer, which inhibits the

purchase because people think the food is contaminated, when they actually do not become radioactive through the use of the technique. Second difficulty is investment for an irradiation facility which is high (approximately U.S. $ 4 million).
There are few facilities that provide this service in Brazil, and the knowledge of the technique among small farmers is still low. As there are few facilities, the logistics cost for these products is higher, which impacts the final price of goods. The technique is used in a limited range of products.

Sterilization by gamma rays having been done in Brazil for many years and some examples are executed by the company whose activities are CBE Embrarad sterilization:

- Medical Products and hospital pharmacists, veterinary
- lab accessories, packaging,
- cosmetics,
- food,
- medicinal herbs,
- animal nutrition,
- dental implants,



Fontes: CBE e EnvironmentalChemistry.com

Some Details of Gamma Ray sterilization

1- Room protected by concrete walls 2m in width to prevent the escape of gamma rays
2- Products already packaged are driven by a belt to sealed sources of cobalt 60 without human contact.
3- The sealed cobalt 60 source emits electromagnetic waves short (gamma rays in contact with microorganisms, causes unrest and destruction of DNA strands, killing them
Products already treated are routed to their final destination without the need for quarantine.

Main Countries and its research reactors that supply radioisotopes (few and old ones)

- Canada – NRU, operating since 1957, around 50% of world production;
- Netherlands - HFR at Petten– 1961, 25 % (shut down);
- South Africa - Safari at Pelindaba, 1965, 10 %;
- Belgium - BR2 at Mol – 1961, 9%;
- France - Osiris at Saclay – 1965, 5%.

South Africa’s reactor (Safari) was converted in 2009 to use low-enrichment uranium only (less than the usual 20% of such type of reactor), in an attempt to reduce the costs of this activity.

Brazil is not self-sufficient in radioisotope production for nuclear medicine - and every year imports US$ 32 million worth of molybdenum 99, from which the radiopharmaceutical used in exams is obtained. With the outage of the Canadian reactor, Brazil has met part of its demand by purchasing the radioisotopes it needs.

A solution to the problem would be the Brazilian Multipurpose Reactor – RMB. Its implementation (around 5 years at a cost of 500 million dollars) could meet this demand and that of other industries in Brazil, seeing that, besides radioisotope production, the RMB would be used in irradiation tests of materials and fuels and in research with neutron beams. This project would contribute to the development of a scientific and technological framework essential to support the expansion of the Brazilian nuclear program.

The Brazilian Multipurpose Reactor - RMB, which is being implemented (basic design and conceptual stage) in Iperó - SP, at a projected cost of 950 million dollars and construction time around 5 years, can meet this demand and other Brazil's industrial needs, since, besides producing radioisotopes essential for diagnosis and therapy of various diseases, the RMB will be used in the testing of fuels and materials irradiation in research with beams of neutrons and will still conduct research in various application areas of nuclear technology, including agriculture, food preservation, materials science, energy and the environment.

On 14/12/12 was signed the declaration of public utility land in Iperó that will house the RMB which is part of the strategic goal of the Ministry of Science Technology and Innovation (MCTI) and is aligned with the policies established in the Brazilian Nuclear Program (BNP). The area ceded by the state government, 800 thousand square meters, adds up to 1.2 million square meters donated by the Navy, totaling two million square feet will occupy the RMB. Of this total, 600 thousand square meters consist of preserved area.

According to Prof. José Augusto Perrotta – Assistant to the President, National Nuclear Energy Commission – CNEN, the reactor is intended to give the country a strategic infrastructure to support development of autonomous nuclear sector activities, particularly self-sufficiency in the production of radioisotopes for use in nuclear medicine. The project is undergoing public hearing by IBAMA (October 2013). The site is located in Iperó, beside the Navy's Aramar Experimental Center that includes the propulsion reactor and all fuel cycle plants being developed by the Brazilian Navy. These initiatives are likely to lead to the development of a nuclear technology hub in the region. Given that all nuclear technology is interconnected, a research reactor will help in activities relating to uranium enrichment and nuclear fuel production, by means of irradiation testing the fuel itself and rods, pressure vessel walls, etc. In addition, it can be used in studies of metal alloys, magnetic components, etc.

At present, Brazil has only four research reactors and four cyclotrons in operation. The research reactors are In São Paulo (at IPEN →IEA-R1 and MB-01), Rio de Janeiro(at IEN→Argonauta), Belo Horizonte (at CDTN→IPR-1), noting that the production of radioactive elements is a monopoly of the federal government, according to Brazil's constitution. The Energy and Nuclear Research Institute - IPEN produces 21 radioisotopes and 15 types of lyophilized reagents (for labeling with Tc-99m).
In August 2010, the president of CNEN and the Secretariat for Strategic Matters, under the President of the Republic's Office (SAE/PR), signed a memorandum of cooperation for research and study on the method of separating natural isotopes of molybdenum by means of ultra short

pulse laser. This constitutes an important toward the localization of molybdenum production and, consequently, the use of radioisotopes for diagnosis in nuclear medicine.

Reactor OPAL, in Australia
Reference for RMB

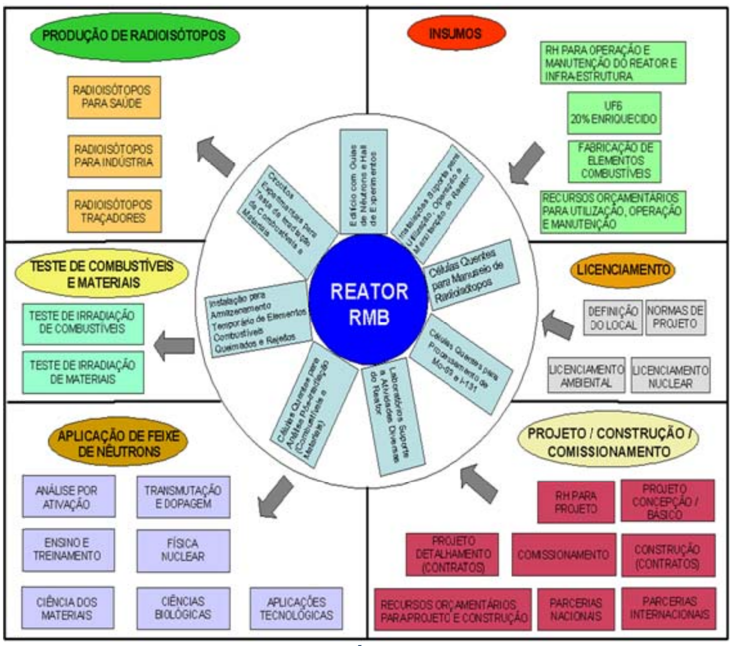


Image - Prof. José Augusto Perrota

In September 2010, the International Atomic Energy Agency (IAEA) approved the proposal from the Radiopharmaceuticals Division of the Nuclear Engineering Institute (IEN), in Rio de Janeiro, to study the feasibility of an alternative, more cost effective method of iodine-124 production. This radioisotope has been researched in a number of countries for use in positron emission tomography (PET), which is considered a state-of-the-art imaging technique. The advantage of iodine-124 over fluorine-18 – the most extensively used radioisotope in PET examinations – is its longer half-life, 4.2 days. For comparison, that of fluorine-18 is less than two hours. This means that the use of iodine-124 can help democratize the access to PET, in that it allows the examination to be conducted at sites more distant from production centers. Due to this radioisotope's longer half-life, the logistics of distribution is also significantly facilitated.

IEA-R1m -CNEN/IPEN -São Paulo- Brazil

IPEN/MB-01 - São Paulo - Brazil

XI – Decommissioning

Every power plant, whatever its fuel, is designed for a specific useful lifetime, after which it will be no longer economical to operate it.

The term decommissioning is used to describe all administrative and technical actions associated with the end of the operating life of a nuclear facility and its subsequent dismantling to facilitate the appropriate removal of regulatory controls (“permit to decommission”).

These actions involve decontamination of structures and components, dismantling of components, demolition of buildings, remediation of any soil contamination and removal of resulting wastes.

All over world there exist around 560 nuclear electricity generation plants which are or have been in operation. Out of these, 133 are in permanently shut down status and at some stage of decommissioning.

Around 10% of these shut down plants have already been completely decommissioned, including 8 reactors of more than 100 MWe each. A large number of other facilities and plants for uranium extraction and enrichment, fuel fabrication, research facilities, reprocessing, and laboratories have been shut down and decommissioned.

The table below shows the reactors shut down for political reasons. According to the WNA, they have been or will be decommissioned. Here we are not listing eight (Kruemmel, Brunsbuettel, Biblis A and B, Isar 1, Neckarwestheim 1 and Phillipsburg 1) in Germany because they can still work sometimes.

<table>
<tr><th colspan="6">Reactors closed prematurely for political reasons (25 units)</th></tr>
<tr><th>Country</th><th>Reactor</th><th>type</th><th>MWe net</th><th>years of operation</th><th>date of clousure</th></tr>
<tr><td>Armenia</td><td>Metsamor 1</td><td>VVER-440/V270</td><td>376</td><td>13</td><td>1989</td></tr>
<tr><td rowspan="2">Bulgary</td><td>Kozloduy 1-2</td><td>VVER-440/V230</td><td>408</td><td>27, 28</td><td>dez/02</td></tr>
<tr><td>Kozloduy 3-4</td><td>VVER-440/V230</td><td>408</td><td>24, 26</td><td>dez/06</td></tr>
<tr><td>France</td><td>Super Phenix</td><td>FNR</td><td>1200</td><td>12</td><td>1999</td></tr>
<tr><td rowspan="3">Germany</td><td>Greifswald 1-4</td><td>VVER-440/V230</td><td>408</td><td>10, 12, 15, 16</td><td>1990</td></tr>
<tr><td>Muelheim Kaerlich</td><td>PWR</td><td>1219</td><td>2</td><td>1988</td></tr>
<tr><td>Rheinsberg</td><td>VVER-70/V210</td><td>62</td><td>24</td><td>1990</td></tr>
<tr><td rowspan="3">Italy</td><td>Caorso</td><td>BWR</td><td>860</td><td>12</td><td>1986</td></tr>
<tr><td>Latina</td><td>GCR</td><td>153</td><td>24</td><td>1987</td></tr>
<tr><td>Trino</td><td>PWR</td><td>260</td><td>25</td><td>1987</td></tr>
<tr><td rowspan="2">Lithuania</td><td>Ignalina 1</td><td>RBMK LWGR</td><td>1185</td><td>21</td><td>2005</td></tr>
<tr><td>Ignalina 2</td><td>RBMK LWGR</td><td>1185</td><td>22</td><td>2009</td></tr>
<tr><td rowspan="2">Slovakia</td><td>Bohunice 1</td><td>VVER-440/V230</td><td>408</td><td>28</td><td>dez/06</td></tr>
<tr><td>Bohunice 2</td><td>VVER-440/V230</td><td>408</td><td>28</td><td>dez/08</td></tr>
<tr><td rowspan="2">Sweden</td><td>Barseback 1</td><td>BWR</td><td>600</td><td>24</td><td>nov/99</td></tr>
<tr><td>Barseback 2</td><td>BWR</td><td>600</td><td>28</td><td>mai/05</td></tr>
<tr><td rowspan="3">Ukraine</td><td>Chernobyl 1</td><td>RBMK LWGR</td><td>740</td><td>19</td><td>dez/97</td></tr>
<tr><td>Chernobyl 2</td><td>RBMK LWGR</td><td>925</td><td>12</td><td>1991</td></tr>
<tr><td>Chernobyl 3</td><td>RBMK LWGR</td><td>925</td><td>19</td><td>dez/00</td></tr>
<tr><td>USA</td><td>Shoreham</td><td>BWR</td><td>820</td><td>3</td><td>1989</td></tr>
</table>

According to the WNA - World Nuclear Association, the following reactors have been or will be decommissioned due to accidents that somehow impaired them:

Reactors closed after an accident (11 units)						
Country	Reactor	type	MWe net	years of operation	date of closure	Reason
Germany	Greifswald 5	VVER-440/V213	408	0,5	nov/89	Partial melting of the core
	Gundremmingen A	BWR	237	10	jan/77	Operational Error on shutdown of the reactor
Japan	Fukushima Daiichi 1	BWR	439	40	mar/11	Melting Core for loss of cooling
	Fukushima Daiichi 2	BWR	760	37	mar/11	Melting Core for loss of cooling
	Fukushima Daiichi 3	BWR	760	35	mar/11	Melting Core for loss of cooling
	Fukushima Daiichi 4	BWR	760	32	mar/11	destruction by Hydrogen explosion
Slovakia	Bohunice A1	Prot GCHWR	93	4	1977	Reactor damaged by the fuel load error
Spain	Vandellos 1	GCR	480	18	jun/90	Turbine fire
Switzerland	St Lucens	Exp GCHWR	8	3	1966	Melting Core
Ukraine	Chernobyl 4	RBMK LWGR	925	2	abr/86	Fire and Melting Core
USA	Three Mile Island 2	PWR	880	1	mar/79	Partial melting of the core

There exist other 97 reactors in the world that will be decommissioned as they have reached the end of their operational life.

Details for the decommissioning of the central **Fukushima Daiishi**

In December 2011 the company Tepco (Tokyo Electric Power Co.) said it plans to start decommissions reactors 1-4 of Central Fukushima Daiishi removing spent fuel from the reactor number 4. The decommissioning program should last between 30 and 40 years. The removal of spent fuel from reactors 1-3 should begin in December 2013.
There will also be 2014, the construction of a wall along the coast in front of the NPP to contain any possible leak of contaminated ground water into the sea.

The activities were divided into 3 stages:

1. One. By 2013 - Research and development to deal with the fragments of the damaged reactors as well as treatment and disposal of nuclear waste arising.
2. In the 10 years following the three buildings will be decontaminated and repaired the reactor containments of reactors. Will begin the work of dismantling
3. . In 40 years should be finished dismantling and disposal of waste.

On December 26, 2011 three Japanese vendors reactors (Hitashi-Ge; Mitisubishi and Toshiba) have joined the Japanese government and Tepco in the process of decommissioning this plant. They will split costs and research activities.

XII – Conclusions

Two and a half years on, it is clear that the use of nuclear power will continue to grow in the coming decades, although growth will be slower than was anticipated before the accident. Many countries with existing nuclear power programmes plan to expand them. Many new countries, both developed and developing, plan to introduce nuclear power. The factors contributing to this growing interest include increasing global demand for energy, as well as concerns about climate change, volatile fossil fuel prices, and security of energy supply. It will be difficult for the world to achieve the twin goals of ensuring sustainable energy supplies and curbing greenhouse gases without nuclear power.

The IAEA helps countries that opt for nuclear power to use it safely and securely. Countries that have decided to phase out nuclear power will have to deal with issues such as plant decommissioning, remediation, and waste management for decades to come. The IAEA also assists in these areas.

The economic growth, prosperity and increasing population will necessarily lead to the growth of energy consumption over the next decades. In an interview on November 9, IEA executive director Maria van der Hoeven said that countries should be honest with their citizens on the impact that decisions for abandoning nuclear energy will bring on energy supply security, if imports will happen, from where, from which source, for how long, how will be transmitted, etc. According to her, these issues involve limited solution options.

According to the IAEA Director General, Yukiya Amano, the rate of expansion of nuclear plant construction could diminish as a consequence of Fukushima, but nuclear energy generation will keep growing. According to UNO, 2012 was the International Year for Sustainable Energy for All, and no source should be disregarded.

The main consequence from the shutdown of operational plants in some countries, as Germany, will be the loss of billion dollars' worth in investment already made, instability in energy production and distribution systems, loss of competitiveness for industry and the economy, loss of jobs, and the increased cost of energy for the population.

The authorities' alleged declaration that they are concerned about safety is unfounded. Not a single death has occurred from radiation exposure at Fukushima, whereas the ensuing earthquake and tsunami (leading to the accident) caused more than 20,000 deaths in the region. According to the Japanese government, only 8 persons out of a staff of 3,700 were exposed to radiation, but no major damage to their health is expected (up to 1% of likely damage in the future).

Expanding electricity supply and simultaneously reducing the effects of climate change is the challenge faced by energy policy planners. Replacing 137 nuclear reactors that will reach the end of their useful lifetimes over the next 20 years by either new nuclear or different energy sources, is the issue that will require very significant investment of all countries concerned. Geopolitical factors involving energy supply cannot be neglected either, and in many cases, nuclear energy is the sole option that affords each country greater security of supply, less dependence on fuel imports, and smaller exposure to the volatility of oil prices.

If nuclear energy is to be part of the future, the industry must overcome the great challenges ranging from difficulties in the supply of materials such as large forgings to the lack of skilled manpower in nuclear engineering and other related disciplines, besides the ageing of difficult to replace specialists.

The interest in developing new nuclear plants has been growing around the world. In addition to those countries that currently run nuclear power plants, 65 others have expressed interest in nuclear electricity generation, mainly if one takes into account the amount of electricity that can be generated without more pollutant emissions and in a very limited physical space. The use of nuclear energy for hydrogen production, electric transport systems, desalination or other nontraditional applications will bring additional demands to bear on the design of advanced reactors, which will be smaller, less expensive, more simplified and planned to run on more efficient thermodynamic cycles.

The technical workforce, with accumulated knowledge and experience, is companies' most important asset, especially in the nuclear area. Today, there exists a one-generation gap in terms of nuclear education which the industry is challenged to overcome. Several countries are seeking to train new engineers and technicians, as indicated by the initiative of the U.S. Department of Energy - DoE, which has set up a university program in nuclear energy where, among other actions, students are offered scholarships and fellowships of up to 150 thousand dollars. THE NRC – Nuclear Regulatory Commission also has a similar program.

Some proposals such as from the European Safety Organizations which created an institute to provide specific training associated with their needs in the fields of safety and radiology are actions to diminish future problems. World prosperity in a carbon free economy necessitates a shift in usual sources of energy, and certainly there exist many ways to that end, but nuclear are the most promising option.

Carbon free sources should not be viewed as competing with one another, but as partners in facing the challenge to provide the world with clean and abundant energy.

XI – Major Sources of Information

- IAEA 2013, Country Nuclear Power Profiles
- Nuclear Technology Review 2013 (NTR 2013)
  http://www.iaea.org/Publications/Reports/index.html#ntr
- Nucnet - several
- Nucleonics Week e NuclearFuel - several
- IAEA PRIS - *http://www.iaea.org/programmes/a2/index.html*
- WNA – World Nuclear Association *- http://www.world-nuclear.org/*
  http://world-nuclear.org/NuclearDatabase/Default.aspx?id=27232
- NRC- Nuclear Regulatory Commission – USA
- *http://www.nrc.gov/reactors/new-reactors/col/new-reactor-map.html*
- INB – Indústrias Nucleares do Brasil – *http://www.inb.gov.br*
- Empresa de Pesquisa Energética –EPE – *http://www.epe.com.br*
- IAEA Publications - *http://www.iaea.org/Publications/Booklets/NuclearPower/np08.pdf*
- NRU*: http://www.nrucanada.ca/en/home/projectrestart/statusupdates/nrustatusupdate25.aspx*
- Bélgica - *http://www.ce2030.be/public/documents_publ/CE2030%20Report_FINAL.pdf*
- WNN *http://www.world-nuclear.org*
- WNN http://www.world-nuclear.org/info/Current-and-Future-Generation/Thorium/
- DOE: http://www.eia.gov/forecasts/ieo/pdf/0484(2013).pdf
- TNP *: http://www.un.org/events/npt2005/npttreaty.html*
- European Nuclear Safety Training and Tutoring Institute : *www.enstti.org*
- Energy - Electricity and Nuclear Power Estimates for the Period up to 2030 - *http://bipartisanpolicy.org/library/report/task-force-americas-future-energy-jobs*
- Nuclear Energy – Technology Roadmap - *http://www.iea.org/papers/2010/nuclear_roadmap.pdf*
- Deployed warheads – SIPRI Year Book 2012
- *www.nea.fr/html/rwm/wpdd*
- WWW.word-nuclear.org/how/decomissioning.html
- http://www.friendsjournal.org/earthquake-tsunami-and-nuclear-power-
- Exelon Corp http://www.exeloncorp.com/powerplants/peachbottom/Pages/profile.aspx
- Radiation : http://microsievert.net/
- Radiation risk and realities - http://www.epa.gov/rpdweb00/docs/402-k-07-006.pdf
- WNA - Nuclear Radiation and Health Effects - http://world-nuclear.org/info/inf05.html
- WNA - Environment, Health and Safety in Electricity Generation - http://www.world-nuclear.org/info/default.aspx?id=15882&terms=Severe%20Accidents%20in%20the%20Energy%20Sector
- http://www.fas.org/programs/ssp/nukes/nuclearweapons/nukestatus.html
- http://bos.sagepub.com/content/66/4/77.full.pdf
- http://investorintel.com/nuclear-energy-intel/the-end-of-the-megatons-to-megawatts-program-m2m/#sthash.MdIOWRZf.dpuf