Worldwide Panorama of Nuclear Energy

November Edition 2014

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Introduction

No technology is more enshrouded in myth than nuclear energy. The urgency of addressing global poverty and reducing emissions demands that we consider this technology without ideological blinders. The basic facts of the technology — both good and bad — must be confronted.

Perhaps the key challenge is in representing and communicating uncertainty – what is known, not known and unsure in an uncertain world – to decision-makers seeking certainty. Regardless of the safety concerns of nuclear power, there is no doubt that nuclear power is here to stay. While some countries have put in motion plans to phase out nuclear power, there are many who are actively boosting the growth of nuclear power.

As more countries look to build their first nuclear power plant, the 'build own operate' or BOO model is seriously being considered in some countries for its benefits, which include training, hands-on experience, and financial support.

Russia is a nuclear power market established that is aggressively trying to explore new business opportunities in nuclear expanding markets through Rusatom Overseas, a subsidiary of Russian state-owned Rosatom - Atomic Energy Corporation, founded in 2011 to promote Russian nuclear technology global market. The company intends to use a BOO model to build the first nuclear power plant in Turkey, based on Akkuyu in southern Turkey, due to start in 2015.

This modeling has its advantages and disadvantages depending on the conditions of each country. It is good if the country needs energy quickly and does not have the necessary technological and nuclear skills and/or the financial ability of the process involves. If however the country wants to develop its own nuclear industry, technology and the independence or has specific rules that bar the model (case of the USA) it is disadvantageous. The most significant benefit is undoubtedly financial. Otherwise, the process could be slower in Turkey in the construction of its first nuclear power plant. BOO models can be a great selling point for developing countries, such as Jordan, Bangladesh, Vietnam and Turkey.

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WORLD PANORAMA OF NUCLEAR ENERGY

I – Highlights of the November 2014 Edition

In 2014, up to November

- 438 nuclear power reactors in operation with an installed total net capacity of 375,504 GW(e)
- 71 nuclear power reactors under construction (net capacity of 67,027 MW(e)

Connections to the grid

- Fuqing-1 (1000 MW(e), PWR, China) on 20/08/2014
- Ningde-2 (1018 MW(e), PWR, China) on 04 /01/2014
- Atucha 2 (692MW(e), PHWR, Argentina) on 27 /06/2014
- Fangjiashan-1 (1000 MW(e), PWR, China) on 04/11/2014

Construction starts

- Carem 25 (25 MW(e), PWR, Argentina) on 8/02/2014
- Belarussian-2 (1109 MW, Belarus on 26/04/2014
- Barakah-3 (1345 MW, UAE on 24/09/2014

In 2013:

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
- Hongyanhe-2 (1000 MW(e), PWR, CHINA) on 23 /11/2013
- Kudankulam-1 (917 MW(e), PWR, India) on 22 /10/2013
- Yangjiang-1 (1000MW(e), PWR, CHINA) on 31 /12/2013

Construction starts

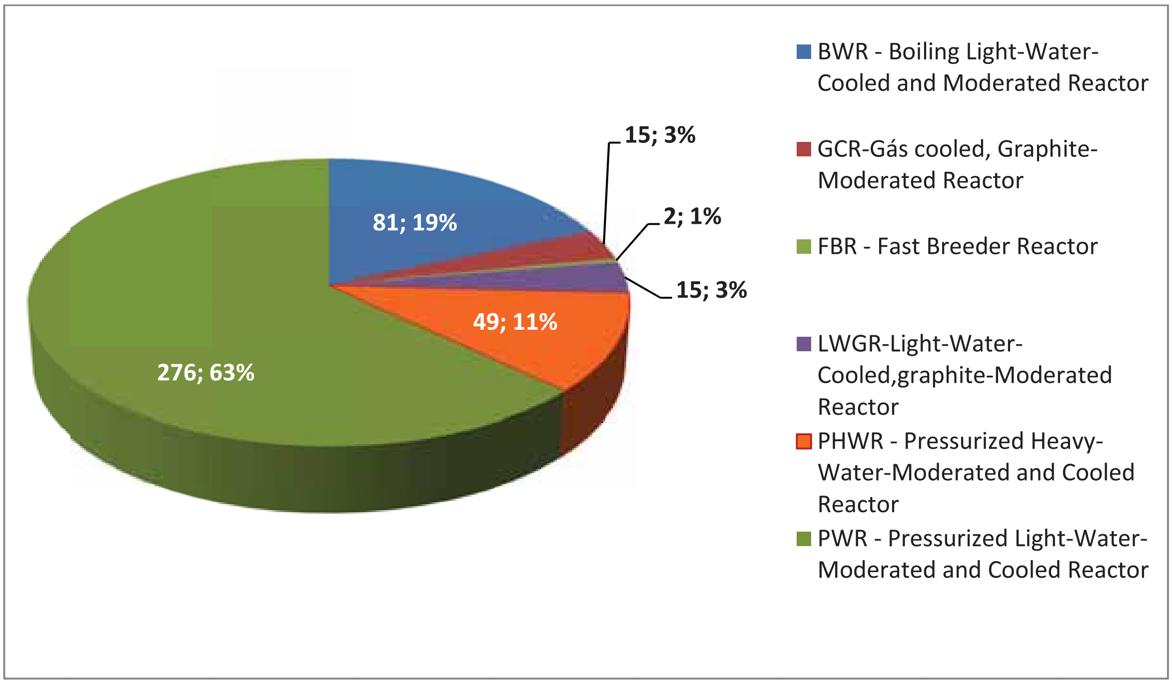
- Virgil C. Summer 2 (1117 MW(e), PWR, USA) on 9 /03/2013
- Virgil C. Summer 3 (1117 MW(e), PWR, USA) on 4 /11/2013
- Vogtle-3(1117 MW(e), PWR, USA) on 12 /03/2013
- Barakah 2(1345 MW(e), PWR, UAE) on 28 /05/2013
- Shin-Hanul-2(1340 MW(e), PWR, KOREA REP.) on 19 /06/2013
- Yangjiang 5 (1000 MW(e), PWR,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

- 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.

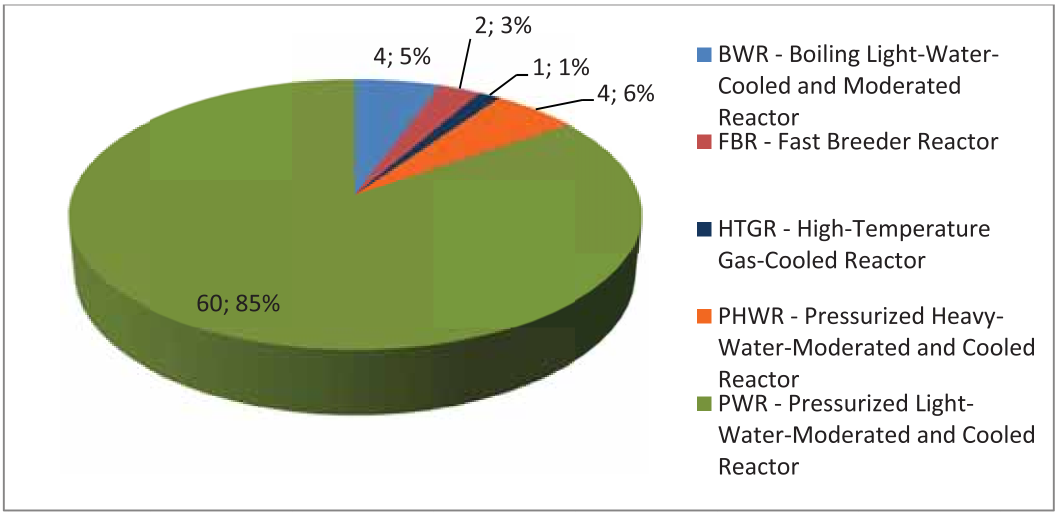
Country	Number of Operated Reactors June 2014	Total Net Electrical Capacity [MW]	Reactor type
ARGENTINA	3	1.627	3 PHWR
ARMENIA	1	375	PWR
BELGIUM	7	5.927	7 PWR
BRAZIL	2	1.884	2 PWR
BULGARIA	2	1.906	2 PWR
CANADA	19	13.500	PHWR
CHINA	23	18.610	PWR
CZECH REPUBLIC	6	3.884	6 PWR
FINLAND	4	2.752	2PWR e 2 BWR
FRANCE	58	63.130	58 PWR
GERMANY	9	12.068	7 PWR; 3 BWR
HUNGARY	4	1.889	4 PWR
INDIA	21	5.308	1 PWR; 2 BWR; 18 PHWR
IRAN	1	915	1 PWR
JAPAN	48	42.388	24 PWR; 24 BWR
KOREA, REPUBLIC OF	23	20.721	19 PWR; 4 PHWR
MEXICO	2	1.330	2 BWR
NETHERLANDS	1	482	1 PWR
PAKISTAN	3	690	2 PWR; 1 PHWR
ROMANIA	2	1.300	2 PHWR
RUSSIA	33	23.643	1FBR;17 PWR; 15 LWGR
SLOVAKIA	4	1.815	4 PWR
SLOVENIA	1	688	1 PWR
SOUTH AFRICA	2	1.860	2 PWR
SPAIN	7	7.567	1BWR e 6 PWR
SWEDEN	10	9.474	7 BWR; 3 PWR
SWITZERLAND	5	3.308	2BWR; 3 PWR
TAIWAN, CHINA	6	5.032	2 PWR; 4 BWR
UKRAINE	15	13.107	15 PWR
UNITED KINGDOM	16	9.243	1 PWR; 15 GCR
USA	100	99.081	35 BWR; 65 PWR
Total	**438**	**375.504**	

438 Reactors in operation by type Country - IAEA – November 2014



Reactors Under construction - IAEA - November 13 th, 2014			
Country	Number of Reactors	Total Net Electrical Capacity (MW)	Reactor Type
ARGENTINA	1	25	1 PWR
BELARUS	2	2218	2 PWR
BRAZIL	1	1245	1 PWR
CHINA	26	25756	25 PWR; 1 HTR
FINLAND	1	1600	1 PWR
FRANCE	1	1630	1 PWR
INDIA	6	3907	1 PWR; 4 PHWR; 1 FBR
JAPAN	2	1325	2 BWR
KOREA, REPUBLIC OF	5	6370	5 PWR
PAKISTAN	2	630	2 PWR
RUSSIA	10	8382	9 PWR; 1 FBR
SLOVAKIA	2	880	2 PWR
TAIWAN, CHINA	2	2600	2 BWR
UKRAINE	2	1900	2 PWR
UNITED ARAB EMIRATES	3	4035	3 PWR
UNITED STATES OF AMERICA	5	5633	5 PWR
Total	71	68,136 MW	

71 Reactors under construction by type – November 2014



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

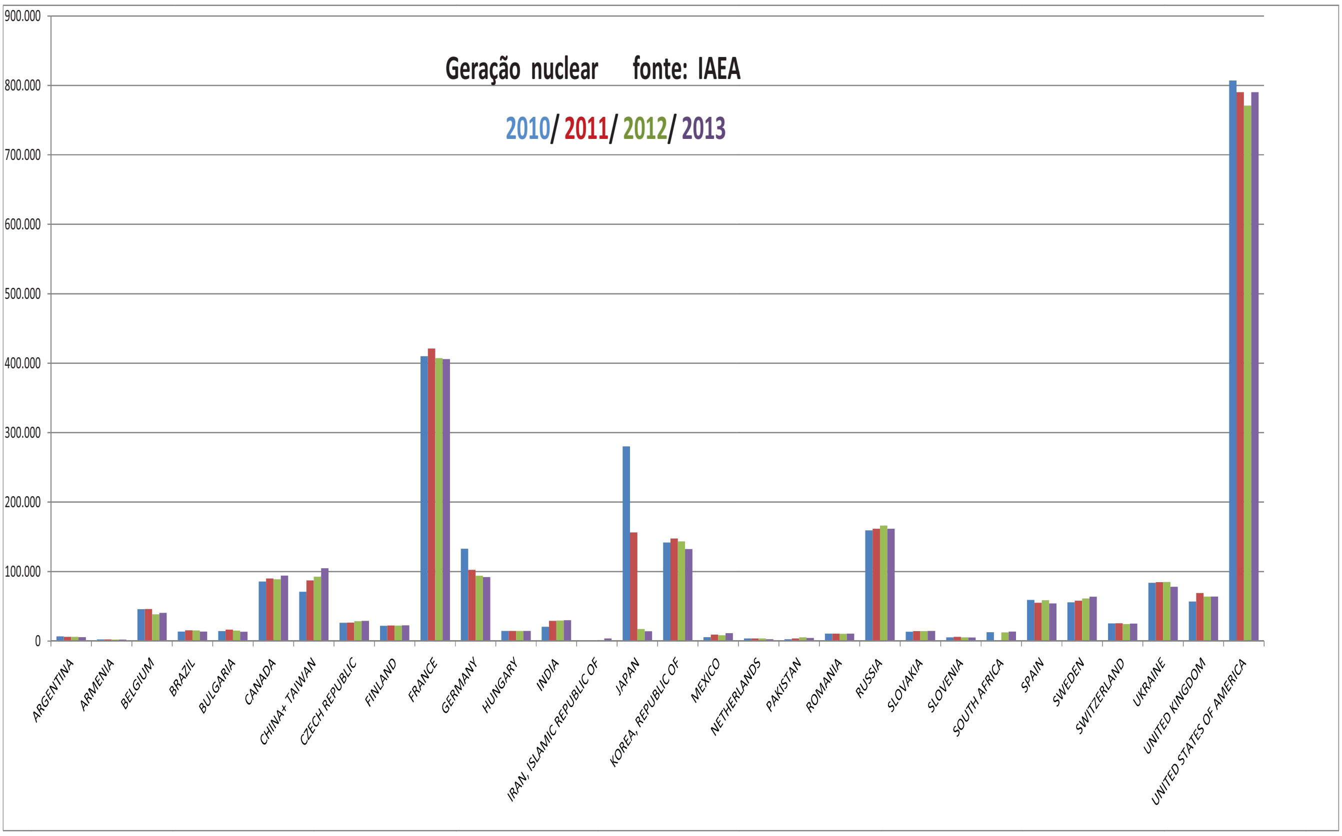
After the accident at Fukushima in Japan in March 2011, the entire nuclear industry mobilized for the evaluation of the event and steps to be taken to ensure that these facts would not repeat in other nuclear power plants. The lessons from the event generated a series of actions as a result of the evaluations 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)

Evaluations undertaken by countries and their regulators generate programs and procedures to solve any weaknesses and have been or are being developed. The main actions are concentrated in areas where there are potential for improvements:

1. Country Regulatory Structure;
2. Seismic resistance evaluation of each reactor;
3. Checking of Tsunami/flood defenses;
4. Install new emergency Diesels;
5. Checking Emergency cooling pumps;
6. Evaluation of Spent Fuel Pool Cooling;
7. Checking of Instrumentation's Spent Fuel Pool;
8. Hydrogen's Recombiners
9. Containment Vent
10. SAMG's (Severe Accidents Management Guidelines)
11. Multi-unit Analysis Emergency Response

The comparison of nuclear power generation in the years 2010 to 2013 shows that some countries have reduced their nuclear generation, but most of them 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 2013, the United States was the country that most generated electricity from nuclear power, accounting for around 33% of the world's total production of such form of energy. Other leading electricity producing countries were: France (17%), Russia (6,8%), South Korea (5,6%), China (4,4%), Canada (4%), Germany 3,91%), Ukraine (3,31%). Brazil was responsible for 0,58% of the world's electricity generation from nuclear power.

France decreased its production of nuclear energy in 2013 that reached 405,989 GWh primarily due to outages longer stops in the period. In Japan, production was 13,947GWh, with huge drop compared to 2011 when it reached 156,182 GWh as a result of the accident at Fukushima Daiichi. Only two reactors were in operation in 2013. Germany produced 92,141 GWh net with small reduction compared to 2011 and 2012 when it reached, respectively, 96,951 and 94098 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.

Country	Total Capacity supplied [GW.h] - 2013	World Contribution [%] - 2013
UNITED STATES OF AMERICA	790.186,82	33,50
FRANCE	405.898,51	17,21
RUSSIA	161.718,08	6,86
KOREA, REPUBLIC OF	132.465,24	5,62
CHINA	104.837,88	4,44
CANADA	94.290,49	4,00
GERMANY	92.141,57	3,91
UKRAINE	78.166,16	3,31
UNITED KINGDOM	64.132,52	2,72
SWEDEN	63.723,40	2,70
SPAIN	54.313,20	2,30
BELGIUM	40.631,96	1,72
TAIWAN, CHINA	39.820,26	1,69
INDIA	30.008,52	1,27
CZECH REPUBLIC	29.005,37	1,23
SWITZERLAND	24.991,83	1,06
FINLAND	22.673,00	0,96
SLOVAKIA	14.623,63	0,62
HUNGARY	14.537,51	0,62
JAPAN	13.947,00	0,59
BRAZIL	13.780,06	0,58
SOUTH AFRICA	13.640,61	0,58
BULGARIA	13.316,11	0,56
MEXICO	11.377,14	0,48
ROMANIA	10.695,75	0,45
ARGENTINA	5.735,22	0,24
SLOVENIA	5.036,47	0,21
PAKISTAN	4.370,93	0,19
IRAN, ISLAMIC REPUBLIC OF	3.893,67	0,17
NETHERLANDS	2.736,93	0,12
ARMENIA	2.167,63	0,09

Participation by country in the world nuclear power generation – 2013

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

Suppliers	Reactors type
General Electric - GE	ABWR / ESBWR
Westinghouse	AP1000
Areva	EPR
AECL	ACR 700
Mitsubish	USA PWR
Toshiba	ABWR
General Atomics	GTMHR
Eskon	PBMR

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 April 2014 the experience gained all over the world by nuclear power reactors (summation of all reactors' years of operation), was more than 15,000 years, with the power generation of around 68,400 TWh.

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.

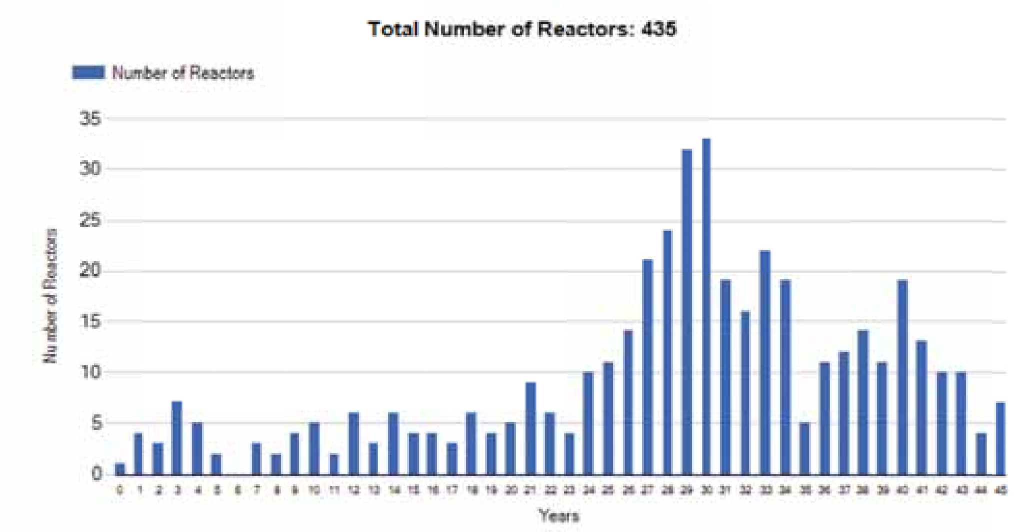
Consortia "Areva/Mitsubishi, Westinghouse-Toshiba, and GE-Hitachi are vendors holding larger production scale and technology to cause real impact on the nuclear industry. Mention should also be made of Korean and Russian companies. Because of the small number of competitors, the market is likely to go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

Apart from small reactors, the following are the main models actively being marketed:

- Areva: EPR, Atmea1, Kerena
- Westinghouse/Toshiba: AP1000, ABWR
- GE Hitachi: ABWR, ESBWR, PRISM
- KHNP: APR1400
- Mitsubishi: APWR
- Rosatom: AES-92, AES-2006, VVER-TOI etc
- Candu: EC6
- CNNC & CGN: Hualong One (from 2014)
- SNPTC: CAP1400 (from 2014)

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.

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 June 2014

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 2013 (TWH)	% of total energy generated in 2013
Canada	19	13,500	0	0	96,97	16

Canada's total nuclear installed capacity up to 2013 was 13,500 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 96,97 TWh or 16% of the country's electricity in 2013. All reactors are PHWR type -pressurized heavy water reactor (CANDU).

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. 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.

NRU at Chalk River – Canada (photo AECL)

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. 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 2013 (TWH)	% of total energy generated in 2013
Mexico	**2**	**1640**	**0**	**0**	**11,377**	**4.6**

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 2013 was 11,377 TWh or 4.6% 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 agreement 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 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 2013 (TWH)	% of total energy generated in 2013
United States	100	99,081	5	5,633	790.186	19.4

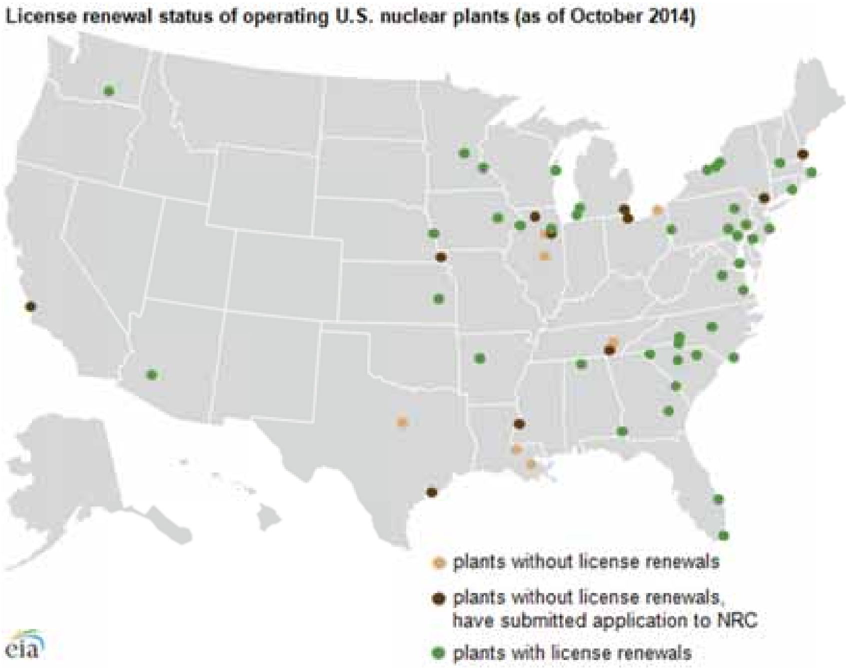
The United States are the owner of the world's largest nuclear fleet, with 104 plants in operation (69 PWRs and 35 BWRs), which correspond to an installed capacity of 107,714 MW in 2012; and in 2012 they produced 769,331 TWh(e). This figure corresponded to more than 32,8% of the world's entire nuclear 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.

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.



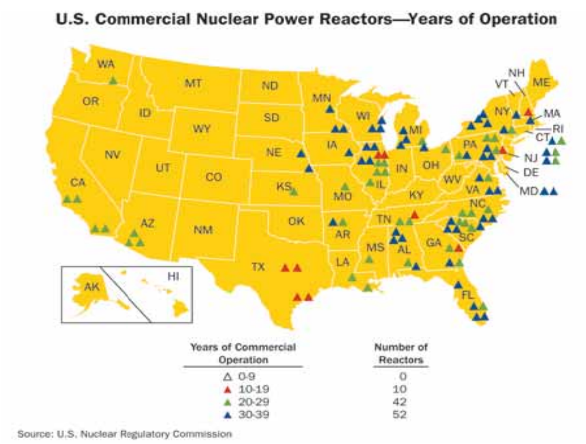
Another relevant fact to be underlined is the increase in the plants’ useful lifetime, which is being extended to 60 years. In this case, **74 units** now have their useful lifetime extended, which is equal to **67,935 MW** functioning for more twenty years, with no capital costs involved in construction. In addition, the NRC – Nuclear Regulatory Commission is reviewing lifetime extension applications for 17 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, 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.

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.



Welding at Watts Bar 2 Steam Generator

Position of American Nuclear Power plant in operation

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.

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.

Central de Vogtle3

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.

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 very competitive price of gas, in particular shale gas, despite environmental restrictions on this technology.

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.

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 2013 (TWH)	% of total energy generated in 2013
Argentina	3	1627	1	25	5,735	4.4

Argentina has 3 operating nuclear power plants - Atucha 1 (PHWR, 335MW), Atucha 2 (PHWR 692MW) and Embalse (PHWR, 600 MW), whose electricity production in 2013, was 5.735 TWh or 4.4% of the country's electricity grid. On the same Atucha 1 and 2 site, in Lima, nearly 100 km away from Buenos Aires, CAREM25 (PWR 25 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 remained in the pre-operational testing phase until June 2014. In July 2014 Atucha 2 (renamed 'Kirchner') was connected to Argentine Grid and sent its first rated power to the electricity grid.

The construction of reactor CAREM25 - Central Argentina de Elementos Modulares, began in February 2014. It is an Argentina prototype reactor design proposed by INVAP, a technology company, which can be used as a generator of electricity (25 MW) research reactor with up 100MWt or desalination with power up to 8 MW in cogeneration. The CAREM prototype is expect to cost $446 million. It is scheduled to begin cold testing in 2016 and receive its first fuel load in the second half of 2017. It relies on passive safety systems, with the entire primary coolant system in a single self-pressurised vessel, using free convection to circulate the coolant.

On September 3rd 2014, a commercial framework contract for the construction of a **third reactor** at the Atucha site has been signed between Nucleoeléctrica Argentina and China National Nuclear Corporation (CNNC). In the contract CNNC will provide technical support, services, equipment and instrumentation under a $2 billion long-term financing arrangement. In addition, China will also supply materials needed by Argentina to locally produce components for the unit. Through the contract, the parties agree that Nucleoeléctrica, as the reactor owner and architect engineer of the project, will conduct pre-project, design, construction, commissioning and operation of the new 800 MWe Candu 6.

Argentina also has five research reactors (RA0, RA1, RA3, RA4, RA6) for applications, training of manpower, materials irradiation and radioisotope production. It has still the RA-10 (30 MW) project that will reset the RA3 (from 1967), besides producing radioisotopes, with operation foreseen for 2018.

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%.

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.

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

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.

In January 2014, Argentina was chosen to be the president of the Nuclear Suppliers Group - NSG (Nuclear Suppliers Group) for the period 2014-2015. The NSG is an organization of 48 countries focused on controlling the spread of nuclear technology through trade, thus preventing the proliferation of nuclear weapons.
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.

Brazil

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
Brasil	2	1,990	1	1,405	14.640	2.78

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).

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.

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.

Angra 3 –Reactor Building Status (photo Eletronuclear)

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.

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 EU imports 40% of the nuclear fuel it consumes and 95 percent of the uranium required for fuel production.

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.europa.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 were summarized results of 18 months of comprehensive risk and safety assessments at all 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.

Armenia

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
Armenia	1	375	0	0	2,167	29.2

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 an earthquake.

In 2013 its sole plant in operation produced 2.167 TWh of electricity, which accounted for 29.2% of the country's electricity generation. Armenia is particularly dependent on Russia for trade and energy distribution, its only company was bought by Russian RAO-UES in 2005. 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. The country has conducted the same safety tests as the EU nations, although not being a member of the Bloc.

Austria

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
Áustria	0	700	0	0	0	0

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.

Nuclear Power Station Zwentendorf, Áustria (Closed)

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 2013 (TWH)	% of total energy generated in 2013
Belgium	7	6212	0	0	40,631	52,1

Belgium has two nuclear power stations, Doel with 4 plants (PWR, 2,963 MW) and Tihange with 3 units (PWR, 3,129 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).

40,6 TWh were produced by nuclear source in 2013, which accounted for 52.1 % of the country's electricity generation. 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, and 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). The tests will take 5 years until the start of commercial operation that is planned to be in 2023 at the Belgian Nuclear Research Center-SCK, as part of the Myrrha project. It 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 75 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.

Belarus

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
Belarus	0	0	1	1109	0	0

Belarus's population is 9.6 million and resides in urban areas. The energy production is 99% from fossil fuels. The country was part of the Soviet Union until 1991, when it declared its independence.

Simulation of two units AES-2006
Image: AtomEnergoProekt

In 2011 Intergovernmental agreement between Russia and Belorussia on NPP construction was signed. Two VVER-type reactors, design "AES-2006" of 1200 MW each, at site "Ostrovetskaya" in Grodno province. Start-up of the first unit is planned for 2018, the second – for 2020.
The first safety-related concrete has been poured for the foundation slab of the 1st reactor at the Ostrovets site in Belarus marking the official start of construction of the country's first NPP (07.11.2013).

A full construction license has been issued for the first of two units at the Ostrovets plant in Belarus, allowing the reactor and plant buildings to be built. Concrete for the second unit foundation was poured on 25.04.2014.

Bulgaria

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
Bulgaria	2	1.906	0	0	13,313	30.7

Bulgaria has 2 nuclear power plants (KOZLODUY 5 and 6 – VVER-PWR 1000 MW, each) in commercial operation, which accounted for 13.313 TWh, approximately 30.7%, of electricity generation in 2013.

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.

Nuclear Power Plant 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 Kosloduy (the reactor No. 7).

In December 2013 Westinghouse signed an exclusive agreement with Bulgaria Energy Holding for the AP1000 technology, and will provide all of the plant equipment, design, engineering and fuel. The reactor is projected to be online by 2023.

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 Bulgarian Academy of Sciences in Sofia operated by The Institute for Nuclear Research and Nuclear Energy (INRNE).

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 2013 (TWH)	% of total energy generated in 2013
Rep. Checa	6	3760	0	0	29.005	35.9

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 29.005 TWh in 2013, accounting for 35.9% of the country's electric power.

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.

Temelín nuclear power plant (foto ČEZ)

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. After this big delay, the company CEZ decided to cancel the project because the government did not give a guaranteed price for energy that justifies the investment amount. The current status is the government takes over the project through a new state company to ensure energy supply in 2020.

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).

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

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 2013 (TWH)	% of total energy generated in 2013
England	16	9,243	0	0	64,13	18,3

The United Kingdom has 16 plants in operation (9243 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 2013, the country produced 64.13 TWh of energy from nuclear source (18.3% 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.

Proponent	Type	Locality	Site	Capacity (MWe gross)	Start Up
EDF Energyn	EPR	Somerset	Hinkley Point C-1	1670	2023
	EPR		Hinkley Point C-2	1670	2024
EDF Energyn	EPR	Suffolk	Sizewell C-1	1670	?
	EPR		Sizewell C-2	1670	?
Horizon	ABWR	Wales	Wylfa Newydd 1	1380	2025
Horizon	ABWR		Wylfa Newydd 2	1380	2025
Horizon	ABWR	Gloucestershire	Oldbury B-1	1380	late 2020s
Horizon	ABWR	Gloucestershire	Oldbury B-2	1380	late 2020s
NuGeneration (Toshiba + GDF Suez)	AP1000 x3	Cumbria	Moorside	3400	2024 on
Total planned & proposed	11 units		15,600 MWe		

source: WNA June - 2014

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. The current UK electricity mix is dominated by fossil fuels and so increasing the share of nuclear would help diversify the UK's fuel security risk.

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.

Hinkley Point C (illustration- WNA)

Company Horizon Nuclear Power - joint venture originally 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.

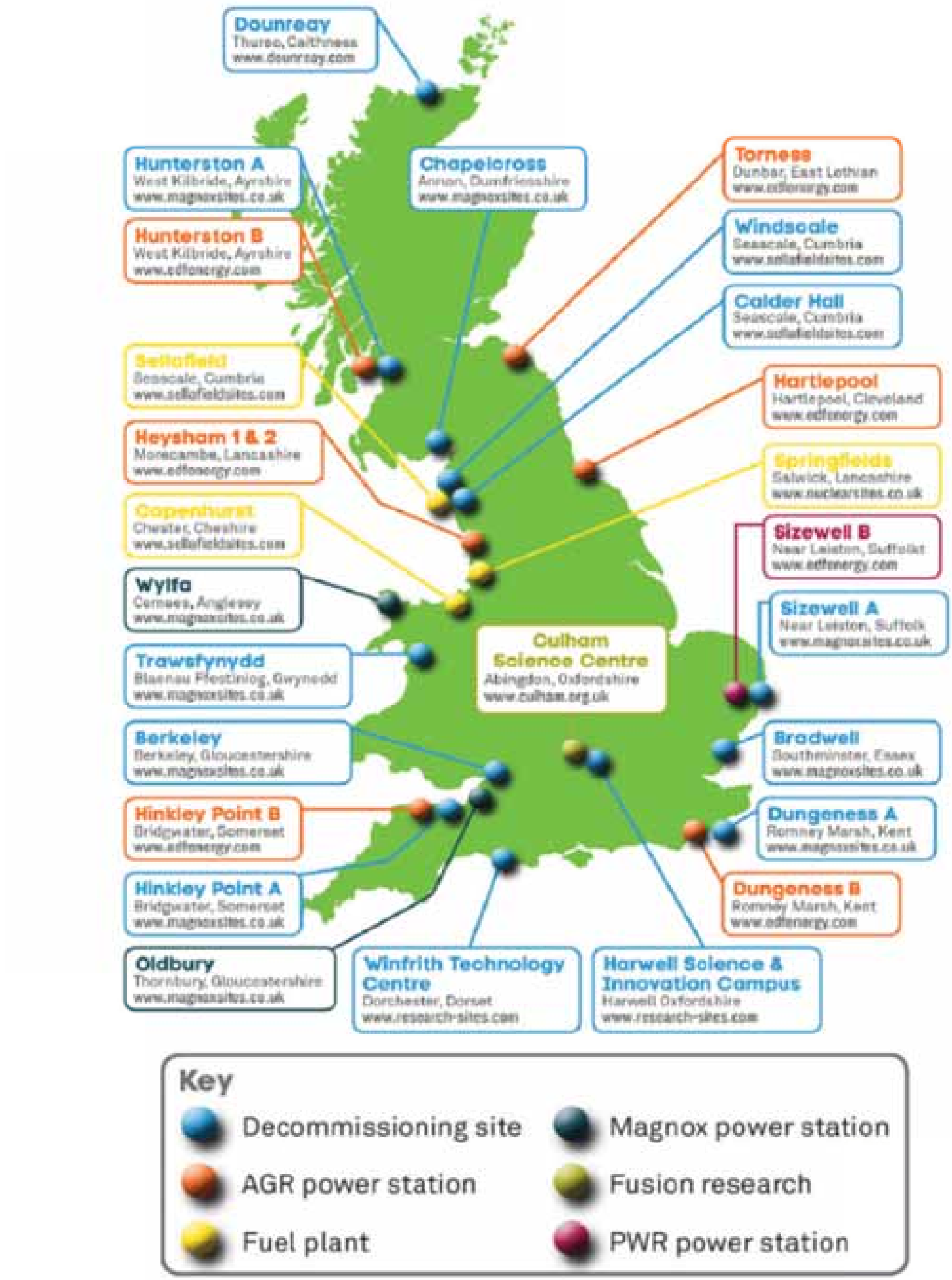
Applications for the three main environmental permits required to operate the proposed new UK nuclear power station at Hinkley Point C in Somerset have been given positive assessment by the country's Environment Agency, EDF has announced and in December 2012 the British regulators approved the EPR project.

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.

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

Following news that Toshiba Corporation has agreed to buy a 60 per cent share in the UK's NuGeneration Limited (NuGen) in Moorside project, Westinghouse Electric Company has reported that it will supply the new-build project with three AP1000 nuclear reactors with a combined capacity of 3.4 GW. GDF Suez is also working in partnership with Toshiba and NuGen on the project.

In November 2014 the EU gave its agreement to the new Hinkley Point.



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. On 5/07/2011 - Britain's Minister of Energy and Climate Change,

Charles Hendry, states that "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 thinks 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. This site comprises of a range of nuclear facilities, including redundant facilities associated with early defence work, as well as operating facilities associated with the Magnox reprocessing programme, the Thermal Oxide Reprocessing Plant (Thorp), the Sellafield mixed oxide (MOX) fuel plant and a range of waste treatment plants.

At present, the country's stockpile of Plutonium comes to 82 tons, 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 2013 (TWH)	% of total energy generated in 2013
Finland	4	2.752	1	1.720	22,673	33,3

Finland has 5.42 million inhabitants and four plants in operation which, together, account for the production of 22.67 TWh of electricity or 33.3% of the country's total electricity generated in 2013; 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 years reached an average of 94.65%.

Nuclear Power Plant Olkiluotto (simulation with 4 reactors - AREVA)

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

The country has reserves of uranium (26.000tU), but it has no uranium mine in operation.

In July 2010, the Finnish parliament approved the country's 6th reactor and in July 2011 the power plant Olkiluoto 2 was uprated to 880MW.

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

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 late 2018. It will be the first plant with the EPR reactor design created by French AREVA.

The Project is showing a delay of nearly 7 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.

Nuclear Power Plant Olkiluoto 3 (photo AREVA)

Out of the three companies that submitted environmental impact studies to the national authorities for the fifth reactor, 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. In December 2011 TVO (Teollisuuden Voima Oyj) has decided to start the bidding and engineering phase of the company's fourth nuclear unit at Olkiluoto, Finland.

Fortum Company (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.

Nuclear Power Plant Loviisa - PWR 488 MW, each (photo Fortum)

In December 2013, Fennovoima announced plans to build the reactor, Hanhikivi-1- a Russian-design 1,200-MW AES-2006 PWR, in northern Finland. It is negotiating with Russian state nuclear corporation Rosatom to take a 34% stake in Fennovoima and for Rosatom subsidiary Rusatom Overseas to build the unit. Pyhajoki site preparation work on the Hanhikivi peninsula, northeast Finland, is expected to start construction by 2015.

Pyhajoki site simulation, Nuclear Power Plant Hanhikivi-1 (ROSATOM)

According to a poll, conducted in 2013, some two thirds of the residents, 67 per cent of people in Pyhäjoki, are in favor of Fennovoima's nuclear power plant project.

The reactors have gone through the stress test defined by European Union and the result showed that no major change is needed in Loviisa and Olkiluoto plants due of the experience of Fukushima accident.

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 the country 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.

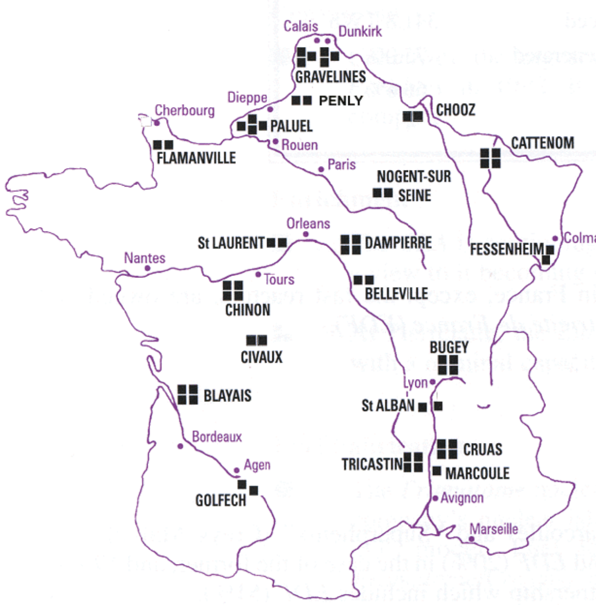
France

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
France	58	63.560	1	1.720	405,989	73,3

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, and the net capacity is 63560 MW. Eleven plants on shutdown (useful lifetime over) produced 405.9 TWh, which represents 73.3% of the country's total generated electricity in 2013. 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 2012 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 CO2 emissions from electricity generation are around 70 to 80 g per kWh, compared with European average of 350g of CO2 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 58 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.
Nuclear plants in France does not operate on the basis of the electrical system, as elsewhere in the world, due to its characteristic of large feeding, being forced to follow load which complicates maintaining the high performance.

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 scrutinized 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.

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), however 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 Euro 50 billion by 2030 without nuclear as government proposed.

It was authorized in July 2011 the extension of life for over ten years for Fessenheim-1 which has been active since 1978 mill. This is the oldest operating reactor Frances. In April 2013 the same was done for Fessenheim-2.

France is targeting decommission the plant until 2016 Chooz A (310MW, PWR), whose energy was provided between 1967 and 1995 for Belgium and for the country itself. The dismantling, cleaning and demolition of nuclear buildings occurred before 2008. Today there are 12 experimental reactors and power being decommissioned. The process has been developed and studied by EdF-CIDEN and should be applied to the entire French nuclear fleet when the useful life of the plants end.

The French government announced an investment plan of € 1 billion in research in nuclear energy and the development and deploying a fourth generation reactor that will be produced by the French Areva and Japan's Mitsubishi and considered to have no alternative to nuclear energy and that "makes no sense" abandon it, but in 2014 the energy transition law passed limited the nuclear share to 50% of the country's total.

Tests conducted after the Fukushima accident demonstrated a good level of security for the French plants according to a report delivered by the regulator. The safety margins for extreme events such as earthquakes, floods, and simultaneous cooling and power losses had showing no major concerns, but nonetheless the operator EdF submitted a supplemental plan for improvements.

Flammanvile - 3 EPR 1600MW (photo Edf)

In February 2013 the French government passed a new regulation (normative full text) that underlies the major nuclear facilities that considers the lessons of the Fukushima accident for nuclear activities.

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.

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.

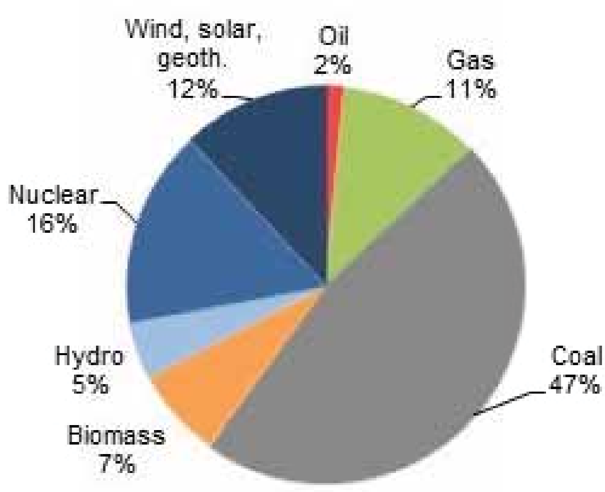
Germany

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
Germany	9	12,068	0	0	92.14	15,14

Germany has a total installed capacity of 161,570 MW, 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 92.14 TWh in 2013, accounting for 15.14% of the country's electricity generation.
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.

Germany's Nuclear Reactors							
Plant	Type	MWe (net)	Commercial operation	Operator	Provisionally scheduled shut-down 2001	2010 agreed shut-down	March 2011 shutdown & 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						

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.

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.

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

In 14 January 2014, The German Supreme Administrative Court has ruled the forced closure of RWE's Biblis nuclear power plant after the Fukushima accident was unlawful. The utility is now likely to sue for considerable damages while the decision may set a precedent for the other shutdown reactors. Germany's reaction to the Fukushima accident in 2011 was extreme and, the orders were executed by the German states which are home to the reactors without consultation or reference to independent regulatory advice on the safety of the plants. With the decision the state of Hesse was told it acted illegally by enforcing the decisions on the Biblis nuclear power plant sited in the state.

The ruling by the Supreme Administrative Court in Leipzig is legally binding and cannot be appealed. It backs up a decision made last year by the Administrative Court of Hesse, which was appealed by the federal government.

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.

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%.

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.

The subsidies received by new wind, biomass and photovoltaic plants average 12 cents per kWh but vary according to the technology: onshore wind plants receive the least - 8.9 cents per kWh - and offshore wind the greatest, 19.4 cents of per kWh. German energy and environment minister Peter Altmaier admitted that the Energiewende (energy transition in German language) could eventually cost up to 1 trillion Euro, with the feed-in tariffs supporting renewable energy possibly accounting for over two-thirds of the cost. (NEI- 6 August 2014)

As Germany has decided to shut down its nuclear power plants after the Fukushima crisis," **due to the imminent risk of tsunamis in Bavaria"**, and as a result, its burning of "clean coal" – otherwise known as coal – rose by 6,5% in 2013, comparing with 2012.

That was despite a massive cut in its exports of electricity to other European countries. One estimate suggests that by 2020, Germany will have produced an extra 300 million tons of CO^2 as a result of its nuclear closure: equivalent to almost all the savings that will be made in the 27 member states as a result of the EU's energy efficiency directive. 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 2013 (TWH)	% of total energy generated in 2013
Hungria	4	1,889	0	0	14,543	50.7

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 50,7% of the country’s electricity generation in 2013. 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.

In 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).

Since 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 expired at the end of 2012 (until 2032). In November, 2014 unit 2 has been granted with more 20 years operation, until 2034.

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.

NPP Paks – Hungary

The decision to expand Paks nuclear power station is to be published in September, 2012, 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. There is no decision about nuclear wastes management, and policy in country is "wait and see".

On 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.

On 14 Jan 2014, Hungary's government has signed an agreement with Russian state-controlled nuclear energy corporation Rosatom that will see the company build two new reactor units at Hungary's Paks nuclear power station. The new units will be financed by a 30-year interstate loan provided by Russia. The size of the loan has yet to be finalized, but will not exceed 10 billion euros (13.6 billion US dollars). Russia would also provide the fuel for the new units.

Italy

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
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 2013 (TWH)	% of total energy generated in 2013
Netherlands	1	482	0	0	2.736	2.8

The Netherlands imports more than 20% of its electricity (mostly from Germany). Energy consumption per capita is 6,500 kWh / year.
The Netherlands has only one nuclear plant in operation (Borssele PWR 482 MW). In 2013, it produced 2.736 TWh, or approximately 2,8 % 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.

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. In 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.


NPP Borssele – Netherlands (Image: EPZ)

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.

On 1 Jul 2014, Borssele nuclear power station has begun to use mixed-oxide (MOX) fuel elements fabricated by France's Areva.

Norway

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
Norway	0	0	0	0	0	0

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).

In June 2013, Thorium fuel was tested in the Halden research reactor in Norway. It was loaded in the last week of April, defining the start of a physical test program that will simulate how it operates in a power reactor.

Poland

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
Poland	0	0	0	0	0	0

The country has a population of 38 million and an electricity mix currently mostly based on coal (94%).To reduce its CO_2 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 3,000MW capacity, with two or three reactors each. It is expected that the first plant will come on stream by 2024 and the second in 2029.

Poland's Ministry of Economy said in May 2014 that Poland is planning to generate 12 percent of its electricity from nuclear by 2030. The final design and licenses are expected to be ready in 2018, allowing construction to start in 2020. According to Prime Minister Tusk, the government believes that nuclear energy is a good alternative for Poland's energy needs, as well as a great business opportunity, with the possibility of selling energy to Germany.

Site in Zarnowiec – Poland

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. The selected technology should belong to one of the competitors - AREVA, GE Hitachi and Westinghouse. On December 9, 2011 Polish state-owned utility PGE said it had decided not to participate in the Visagina's nuclear plant project in Lithuania nor contract for electricity from Russia's proposed Baltic nuclear power plant in Kaliningrad. 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 6,000 MW of nuclear capacity by 2030 and in September 2013 PGE said it will maintain equity of 70% in PGE EJ, with 10% each held by Enea, Tauron and KGHM, and all four parties have initialed an agreement accordingly. The Polish government requested PGE to lead a consortium to build two nuclear power plants at separate sites but there are doubts about to the necessary financing. No contract is signed.

On 30 January 2014, The Polish government has adopted its Polish Nuclear Power Program (PPEJ), which is not a binding plan, but rather a "road map". The program defines, among others, the schedule for construction of two nuclear power plants of 3,000 MW each and preparation for these investments regulatory infrastructure and organization. The program also includes: economic justification for the implementation of the construction of nuclear power in Poland and its financing, and ways of dealing with spent nuclear fuel and radioactive waste. The location of the two units will be selected by the end of 2016; construction is expected to start in 2019 and to be completed in late 2024. The second unit should be commissioned by 2035.

Romania

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
Romania	2	1,300	0	0	10.7	19.82

Romania has 2 nuclear power plants (Cernavoda 1 and 2- PHWR 650 MW) in commercial operation with 19.82% of electricity generation from nuclear reactors in 2013. These are the only CANDU reactors operating in Europe. The two plants are operated by SNN - Societatea Nationala Nuclearelectrica. Units 3 and 4 (720 MWe Candu, each) are going through financing problems and beginning of commercial operation are undefined for both plants.

NPP Cernavoda – Romania

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.

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

Russia

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
Russia	33	23,643	10	9,285	161.781	17.52

Russia has 33 plants (23,643 MW) in operation (15 of them equipped with the RBMK reactor or LWGR – the same model used in Ukraine's Chernobyl plant)and 1 FBR. There are 10 plants under construction (1 FBR and 9 VVER - capacity = 9,285 net) and 22 planned plants with a net capacity of 24,200 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 2013 produced more than 161 TWh of energy or 17.52% of the country's energy. The country's per capita consumption is nearly 3 times greater than Brazil's, for a population of around 142 million inhabitants.
By 2030, 24 plants should end its useful life and many of the new constructions will replace the ones being retired.

Russia also operates a fleet of six large nuclear-powered icebreakers and a 62,000 tonne cargo ship which are more civil than military. It is also completing a floating nuclear power plant with two 40 MWe reactors for use in remote regions.
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.
Oil and gas sales accounted for 68% of Russia's oil exports in 2013.

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.

Reactors Under Construction In Russia				
Name	Type	Location	Reference Unit Power(MW)	Gross Electrical Capacity (MW)
AKADEMIK LOMONOSOV-1	PWR	PEVEK	32	35
AKADEMIK LOMONOSOV-2	PWR	PEVEK	32	35
BALTIC-1	PWR	SOVETSK	1109	1194
BELOYARSK-4	FBR	ZARECHNYY	789	864
LENINGRAD 2-1	PWR	SOSNOVYY BOR	1085	1170
LENINGRAD 2-2	PWR	SOSNOVYY BOR	1085	1170
NOVOVORONEZH 2-1	PWR	NOVOVORONEZHSKIY	1114	1199
NOVOVORONEZH 2-2	PWR	NOVOVORONEZHSKIY	1114	1199
ROSTOV-3	PWR	ROSTOV OBLAST	1011	1100
ROSTOV-4	PWR	ROSTOV OBLAST	1011	1100
Total	Under Construction		10	

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 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.

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.

On 13/06/2013, the project of the Baltic nuclear power plant temporarily stops due reduction in consumes in the region. Reactors of low power are under consideration to meet electricity net system of the Kaliningrad region, of about eight units of 40 MW(e).

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. On November, 11th 2013 Russia has approved a plan to construct 21 new nuclear power reactors in the country by 2030. The new units will have a combined total installed capacity of 25,280 MW. The plan, signed by Prime Minister Dmitry Medvedev, was included in a "regional and territorial energy planning scheme" and published on the government's website November 21.

It includes three developments for the country's nuclear power sector:

- Construction of five new two-unit nuclear power plants, to be called Kostroma, Nizhny Novgorod, Seversky, South Ural and Tatar;
- Construction of replacement capacity at three existing nuclear power plants nearing the end of their operational life, Kola, Kursk and Smolensk; and
- Construction of a Generation IV BN-1200 sodium-cooled fast reactor at Beloyarsk nuclear power plant.

In November 2011, Russia's regulatory body – Rosetekhnadzor awarded the license for the Baltic Nuclear power plant (two reactors VVER 1200MW). Rosatom, Russian state-run nuclear company began in February 2012 the construction of the 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).

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

Control Room of Reactor Leningrad (RBMK or LGWR)

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 2018 and 2020 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.

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

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

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 2013 (TWH)	% of total energy generated in 2013
Slovakia	4	1.815	2	880	14,42	51.7

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.

Nuclear Power Plant 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 2013 (TWH)	% of total energy generated in 2013
Slovenia	1	688	0	0	5,036	33,6

Slovenia has a population of 2 million. Neighbouring Croatia has 4.5 million people. Together they have 1 nuclear reactor - KRSKO (PWR, 688 MW) in operation since 1981. In 2013, KRSKO produced 5.036 TWh of electricity, supplying 33.6 % 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.

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

Nuclear Power Plant KRSKO

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 2013 (TWH)	% of total energy generated in 2013
Spain	7	7,567	0	0	54.31	19.7

Spain has 7 nuclear reactors (6 PWR and 1 BWR) in operation, with a total 7,567 MW installed capacity. In 2013, 54.31TWh of electricity were produced, corresponding to 19,7% 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.

Three 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.
- **Garona - Spain's oldest reactor (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.**

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.


Nuclear Power Plant Vandellos 2 – Spain

In 27 May, 2014 the Garona's operator Nuclenor has submitted a request to renew the operating licence in Spain to the Ministry of Industry, Energy and Tourism, the company has said in a statement.

In November 2014 Spain's Nuclear Regulator Approves Trillo Operating Licence Until 2024

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.

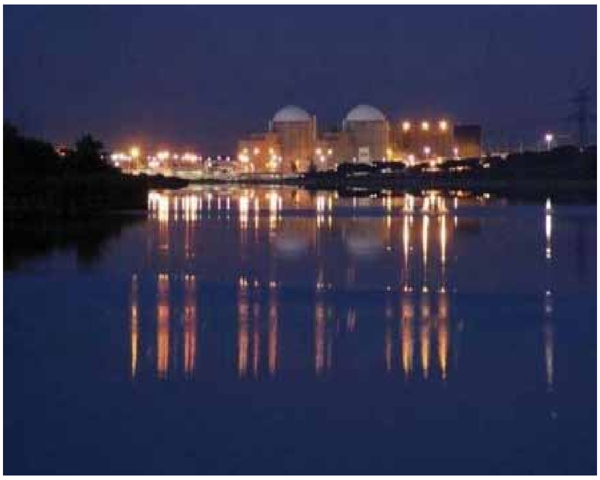
Notwithstanding, in December 2009 a new law was approved which allows plants to operate beyond their original 40 years' useful life, if the country's Nuclear Safety Council declares them to be safe. An example of this was the authorization, in June 2010, to extend the lifetimes of Almaraz-Trillo plants and Vandellos 2, by an additional 10 years.

Nuclear wastes

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.

Nuclear Power Plant Almaraz-Trillo

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). 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. In November 2014, Almaraz-Trillo was grant with more 10 year life operation, until 2014.

The new government elected in November 2011 has already stated that the Spanish electricity mix will be one that ensures the reduction of CO2 emissions.

Sweden

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
Sweden	10	9.388	0	0	63,72	42,7

Sweden has 10 nuclear reactors in operation that produced 63.72 TWh or 42.7 % of electricity in 2013. 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.

Ringhals nuclear power plant is the largest power plant in Scandinavia.

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

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.

Nuclear Power Station Forsmark

Nuclear wastes

With a nuclear generating fleet where all reactors have been operating for twenty two to forty 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.

Östhammar – Sweden Selected site for construction of waste storage

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.
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 2013 (TWH)	% of total energy generated in 2013
Switzerland	5	3.308	0	0	24.99	36,4

Switzerland has 5 operating nuclear reactors (3,352 MW installed capacity) distributed in PWR and BWR type reactors, which produced 24.99 TWh of electricity in 2013, accounting for 36,4% 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.

These 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. Three construction applications for new nuclear plants were under review by Swiss federal authorities when the Fukushima 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.

There was also high support for the continued use of nuclear power, with 68% of people saying that Switzerland's existing reactors should remain in operation as long as they are safe (according with pools in October 2013).Nuclear energy is an essential part of Switzerland's energy mix and more debate is needed about its planned phase out.
The Uranium for fuel that supplies the plants is procured on world markets, enrichment is provided by a variety of contractors, and fuel fabrication is similarly diverse.

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

Nuclear wastes

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 m^3), 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 93,000m^3. 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.

Ukraine

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
Ukraine	15	13.107	2	2.000	78,17	43,6

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.

Zaporizhia Nuclear Power Station

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.

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%.

A 20-year extension of the operating licenses for Rovno 1&2 was granted by the State Nuclear Regulatory Inspectorate of Ukraine (SNRI or SNRC) in December 2010.

According to data from the World Nuclear Association – WNA there exist 13 planned reactors in Ukraine, with 9 being intended to replace older ones scheduled to be shut down by 2035, and the others 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.

On 16 December 2013 - South Ukraine-1 nuclear power plant gets 10-year extension to 2023 The State Nuclear Regulatory Inspectorate (SNRI) of Ukraine has approved a 10-year extension of the operation license for the South Ukraine-1 nuclear power plant.

Ukraine's Reactors in operation				
Reactor	Type V=PWR	MWe net	Start Commercial operation	Scheduled close, likely close
Northwest:				
Khmelnitski 1	V-320	950	Aug 1988	2018, 2032
Khmelnitski 2	V-320	950	Aug 2005	2035, 2050
Rivne/Rovno 1	V-213	402	Sep 1981	2030
Rivne/Rovno 2	V-213	416	jul/82	2031
Rivne/Rovno 3	V-320	950	May 1987	2017, 2032
Rivne/Rovno 4	V-320	950	late 2005	2035, 2050
South:				
South Ukraine 1	V-302	950	Oct 1983	2023, 2033
South Ukraine 2	V-338	950	Apr 1985	2015, 2030
South Ukraine 3	V-320	950	Dec 1989	2019, 2034
Zaporozhe 1	V-320	950	Dec 1985	2015, 2030
Zaporozhe 2	V-320	950	Feb 1986	2016, 2031
Zaporozhe 3	V-320	950	mar/87	2017, 2032
Zaporozhe 4	V-320	950	Apr 1988	2018, 2033
Zaporozhe 5	V-320	950	Oct 1989	2019, 2034
Zaporozhe 6	V-320	950	Sep 1996	2026, 2041
Total (15)	**13,168 MWe net (13,835 MWe gross – Energoatom May 2013)**			

The 950 MW, commissioned in 1983, had been granted a 30-year operation license. With this extension, the unit will continue generating until December 2023. It is currently undergoing pre-startup tests after a 280-day outage during which repairs, reconstruction and modernization work has been undertaken. A similar extension could be granted to the other two units at South Ukraine, until 2015 and 2019, respectively.

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.

In 1991, Ukraine had on its territory 1,900 strategic nuclear warheads along with 176 intercontinental ballistic missiles (ICBMs) and 45 strategic bombers. That constituted the world's third largest nuclear arsenal. Ukraine agreed to give up those weapons, in part due to commitments to Treaty on the Non-Proliferation of Nuclear Weapons - NPT and to have respected its territorial integrity and sovereignty contained in the 1994 Budapest Memorandum signed with Russia, the United States and England.

Other European Countries

Baltic countries (Lithuania, Estonia 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.

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.

In 2014 the Ignalina nuclear power plant's (INPP) Unit 2 commences Unit 2 Turbine Hall equipment dismantling and decontamination. The project must be completed in 2021 June.

Nuclear Power Plant Ignalina-2 equipment dismantling and decontamination

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

There are programs in nuclear manpower training and in the design of small reactors (50 to 200 MW), led by the United States that could be the most economical option for most countries on the continent without resources.

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 was expected that by 2012 authorities had had defined the type and supplier of the future reactor, but the internal conflict had postpone the decision. 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. One of the tender's conditions is that whoever wins will take the responsibility of financing the project till its implementation.

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. Most of this energy (80%) goes to the American company VALCO (Volta Aluminium Company)

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.

Image of first reactor of Jordan (KAERI)

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.

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.

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 (Rosatom), winner of the international competition with model AES92 (VVER 1000). The company will finance 49% of the project with the remainder under the responsibility of the government of Jordan.

The model chosen was AES92 (1000MW VVER). The site will be located in Majdal, 40 km north of Amman, with cooling from a sewage treatment station. Contracts are being prepared but have not yet been signed.

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.

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.

Namibia

Half of the country's electricity is supplied by South Africa, which also faces internal problems of energy supply.

Namibia has no nuclear electricity generation plants, but it is Africa’s top producer of uranium and the world’s fifth 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 begun 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 a total capacity of 2GW (in 2013) and 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.

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.

There is also the possibility of using small reactors (reactors Small) desalination of sea water, as the Argentine CAREM. Several cooperation agreements were signed with suppliers of reactors (GE Hitachi Nuclear Energy and Toshiba / Westinghouse, AREVA and EdF) preparing for international competition that will precede the start of construction of a nuclear power plant.

Russian and Saudi Arabian officials have approved the draft of an agreement on cooperation in nuclear energy, Rosatom announced in a statement June 18, 2014.

South Africa

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013(TWH)	% of total energy generated in 2013
South Africa	2	1800	0	0	1364	5,7

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.

Nuclear Power Station 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.

On September 22, 2014 South Africa and Russia signed a strategic partnership agreement on nuclear energy collaboration, according to Russian state nuclear company Rosatom, but an official in the South African nuclear program emphasized that Russian technology was only one of the options being considered. The agreement lays the foundation for large scale nuclear power plant procurement and development program by South Africa based on the construction in South Africa of Russian VVER reactors with a total installed capacity of up to 9.6 GW (up to eight nuclear Units.

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.

Site Akkuyu – Turkey – pre construction activities

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.

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		?

Planned or proposed Reactors in Turkey **(Source: WNA)**

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).

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.

The main role of nuclear energy in Turkey is strategic, reducing dependence on gas from Russia and Iran. The second plant, scheduled to start operating in 2023, will be located in Sinop.

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	3	4035	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.

Barakah1 and 2 - Under construction

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, 2010 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 was initiated in July 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). The second unit started construction in May 2013, and the third in September 2014.

A third unit is scheduled to be commissioned in 2019 and a fourth in 2020. The construction application for Barakah-3 and -4 was filled also. Safety concrete has been poured for the reactor containment building of Unit 3 in September, 2014.

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

Emirates Nuclear Energy Corp. announced August 15, 2012 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.

On 21 April 2014, The Emirates Nuclear Energy Corporation (ENEC) has celebrated the inauguration of its Simulator Training Center (STC) at Barakah site in the Western Region of Abu Dhabi. The new simulators, which are among the world's most advanced nuclear training devices and the first of their kind in the Middle East, will complement ENEC's comprehensive training program and help ENEC to prepare its scholarships students to attain Reactor Operator (RO) and Senior Reactor Operator (SRO) certifications. They will also provide continuous training for ENEC's working SROs.

Construction continues at the site of the UAE's first nuclear-power plant at Barakah-1 in the Western Region.
Photo courtesy Emirates Nuclear Energy Corporation

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.

There are 700 million people in India and just over 600 million in China who lack sources of energy such as electricity or gas and rely on wood, charcoal or dung. About 85% of the Indian rural population depend on traditional combustible, more dangerous than they may seem. Its steam contains harmful particles that can prejudice the health of those who breathe them, with harmful micro-organisms up to 3,000 per cubic meter, more heavily contaminated than those coming from the pollution of road or industry. The UN warns that India should strive to leave these antiquated fuels, replacing them with electric or gas stoves, thereby remarkably improving the standard of living of the peasants.

China

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (GWH)	% of total energy generated in 2013
China	23	18,998	26	25,756	110.710	2.11

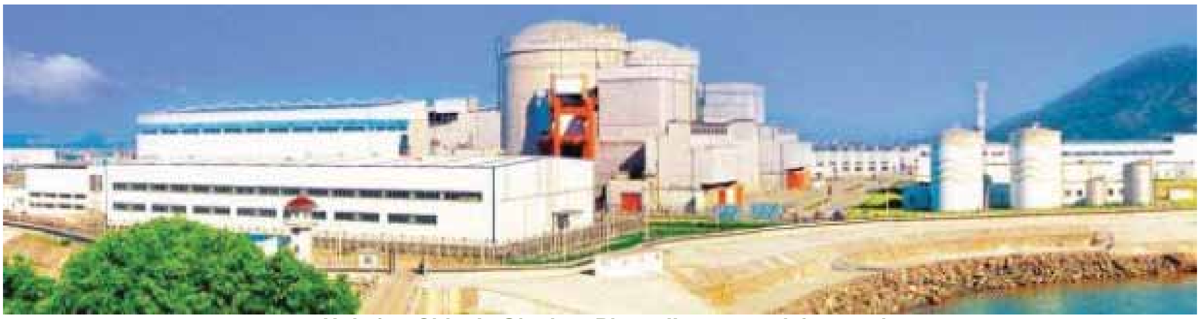
China is today the world's greatest consumer of energy (5,245 TWh in 2013), according to the International Atomic Energy Agency. China's demand for commodities and products is so big that it has a huge impact on the global market. The country has a limited supply of oil and gas, but is rich in coal, and the domestic consumption of such fuel leads to a heavy environmental pressure as to gas emissions. Besides the problems

with emissions of pollutants into the environment, the water supply is precarious and regional disparities lead to internal tensions.
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 coal dependence in electricity generation, thus cutting back as emissions caused by the fossil fuels.

The Beijing Municipal Environmental Protection Bureau has decided to ban coal sale and use in Beijing's six main districts (Dongcheng, Xicheng, Chaoyang, Haidian, Fengtai and Shijingshan) by the end of 2020 to cut air pollution (China).

Coal-fired power plants and other coal facilities will be closed by this date and replaced by gas and electricity for heating, cooking and other uses. Other polluting fuels, such as fuel oil, petroleum coke, combustible waste and some biomass fuel will be also banned. Coal accounted for more than 25% of Beijing's energy consumption in 2012 and should drop to less than 10% by 2017.

In March 2014, Beijing announced a strategic plan aimed at cutting CO2 emissions by 20Mt by 2018 and reducing air pollutants emissions by 25% below 2012 levels by 2017. Beijing also has established an Emission Trading Scheme.



Unit 4 at China's Qinshan Phase II commercial operation

As far as nuclear energy is concerned, the country has, up to September 2014, 22 nuclear power plants in operation (17,998 MW) and the Chinese government contemplates the construction of 200 GW over the next 20 years. According to the IAEA, 27 plants are now under construction (with a total capacity of 26,756 MW) and 16 new reactors have been approved for start of construction.

All large vendors have already submitted offers to the Chinese government, in as much 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.

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.

AP1000 Image

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.

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 2015.

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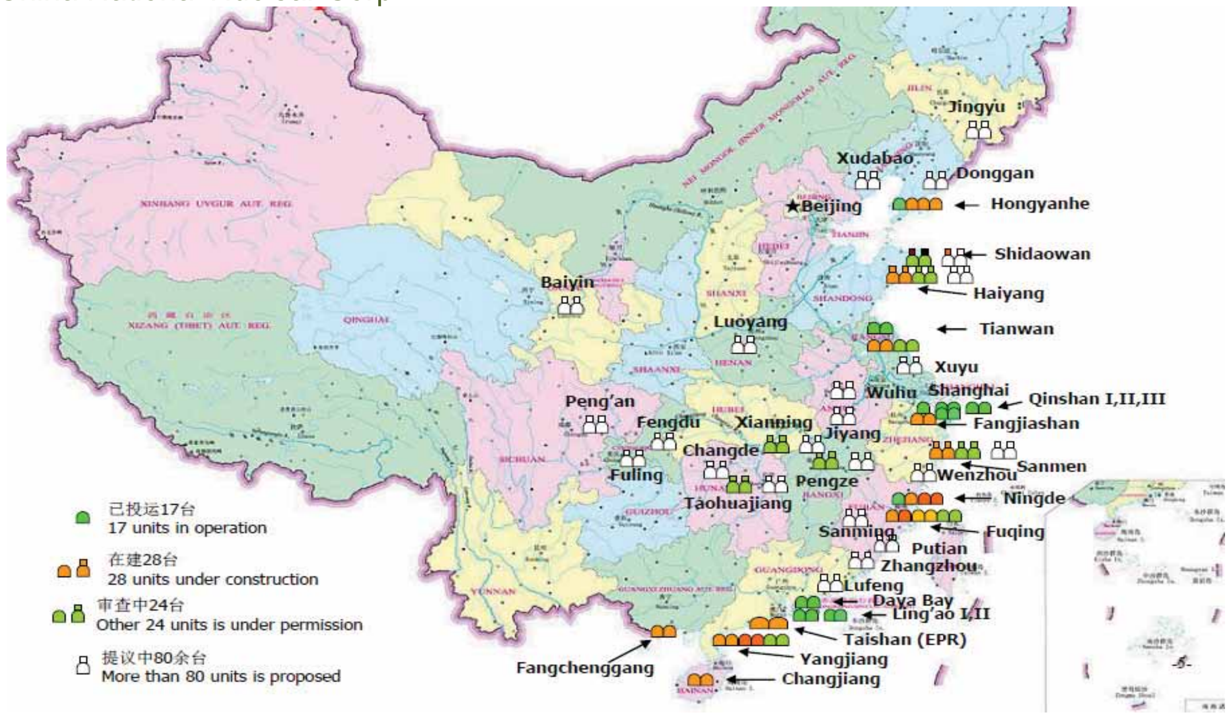
All of this ambitious process is heating up the Chinese nuclear industry, with companies' fast-paced diversification to cope with the government's strategy to attain self-sufficiency as quickly as possible. Today, China's Nuclear Power Institute - NPIC has 6,000 professionals on its workforce, and many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

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.



Location of Nuclear Power plant in China

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%.

NPP Yangjiang

Taishan 1 –EPR 1600 under construction

Nuclear wastes

In line with China's nuclear waste policy that contemplates spent-fuel reprocessing, a pilot plant for 50 metric tons 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.

China's Tianwan unit 1 is now operating on an extended 18-month fuel cycle after being loaded with modified TVS-2M fuel, Russian fuel supplier TVEL has announced. The fuel is currently used in Russia's Balakovo and Rostov power plants, and it received regulatory approval for use in Chinese plants following the successful completion of a pilot study using six TVS-2M assemblies at Tianwan 1. Tianwan 2 is also due to be converted to use the fuel. TVS-2M fuel for use at Tianwan units 3 and 4, still under construction, will be manufactured at China's Yibin fuel plant using technology transferred from TVEL.

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.

Chinese Experimental Reactor - CEFR
(photo : China Institute of Atomic Energy)

On May 21, 2014 the first localized steam generator for the AP1000 unit also passed testing, it said. Snptc said in February that China can build its own versions of the third-generation Westinghouse AP1000 reactor design and has the design capability for the localization of the AP1000.

On August 20th, 2014 the project owner China National Nuclear Corporation said that Fuqing-1 nuclear power reactor (PWR 1000 MW – Chinese type CPR1000) in China's Fujian province was connected to the national power grid for the first time. This is the first unit among 4 that are under construction in the same site to be connected.

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).

China has successfully manufactured its first domestically-made AP1000 reactor pressure vessel, destined for the Sanmen-2 nuclear unit, State Nuclear Power Technology Corp., or SNPTC, said in a June 10, 2014 statement. The vessel for Sanmen-2 also passed testing on June 8, 2014, marking a breakthrough in the localization of third-generation nuclear technology, SNPTC said.

India

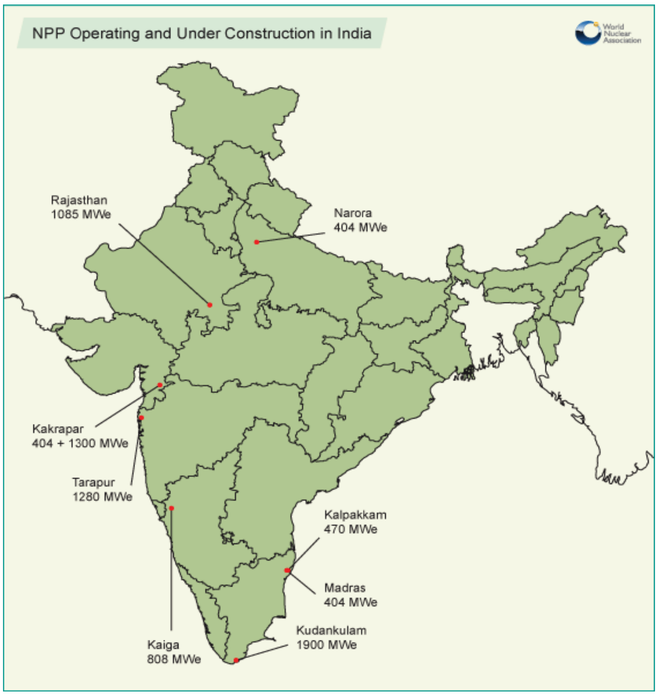
Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
India	21	5308	6	3907	30.3	3,53

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 million people. About 450 millions of people (40% of inhabitants) have no access to electrical energy.

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 (15%) and gas (8%), but to meet the huge energy needs of a country with over 1.15 billion people and whose consumption is only 4% of energy per capita in the United States or 25% of per capita consumption in Brazil much more is necessary.

India has 21 nuclear reactors in operation (5,308 MW) which, in 2013, produced around 3.53% of the country's electricity, or 30.3 TWh. At present there exist 6 plants under construction (3907MW), and an additional ten 700 MW PHWRs and ten 1000 MW LWRs are officially planned and expected to start construction by 2015. The country's installed capacity is estimated to reach 10,080 MW by 2017, at the completion of all construction projects. 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.

13 Jan 2014 (NucNet)- India's prime minister Manmohan Singh has laid the foundation stone for a new nuclear power plant near Gorakhpur village, 200 km east of the capital New Delhi, the Nuclear Power Company of India Limited (NPCIL) has said in a statement. The new station, known as Gorakhpur Haryana Anu Vidyut Pariyojna (GHAVP), will consist of four 700-megawatt (MW) units. They will be indigenously designed pressurised heavy water reactors (PHWR) using natural uranium as fuel. Construction of the station will consist of two stages with the reactors being built in pairs, the Nuclear Power Corporation of India Limited (NPCIL) said. The laying of the foundation stone marks the start of the first phase of construction. Pouring of first concrete for the first unit is expected to be in June 2015 and for the second unit six months later. The two units will be commissioned in 2020 and 2021 respectively.



India Nuclear map –WNA

NPCIL plans to build two other 700 MW PHWR units at Chutka in Madhya Pradesh province, central India. Six 1,000 MW light-water reactors (LWRs) will be built at Mithi Virdi in Gujarat province, about 600 kilometres north of Mumbai as well as another six 1,000 MW LWRs in Kovvada, Andhra Pradesh province, about 400 km East of Hyderabad.

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), 2 PWR and 1 FBR.

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. In September 2014 the country began arrangements to receive uranium from Australia.

The International Energy Agency estimates that nuclear power that today is three percent of India's electricity will grow to 12 percent in 2030 and 25 percent by 2050. India plans to invest 96 billion dollars in nuclear power plants by 2040 with six plants under construction and 57 planned or proposed.
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.

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.

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.

Kudankulam NPP -Two reactors (2x950 MW -VVER) - India. Reactor 1 connected to the grid in October, 2013 (photo: Atomstroyexport)

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 2013 (TWH)	% of total energy generated in 2013
Iran	1	915	0	0	3,89	1,5

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.


NPP Bushehr, Iran (photo : Atomenergoproekt)

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.

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.

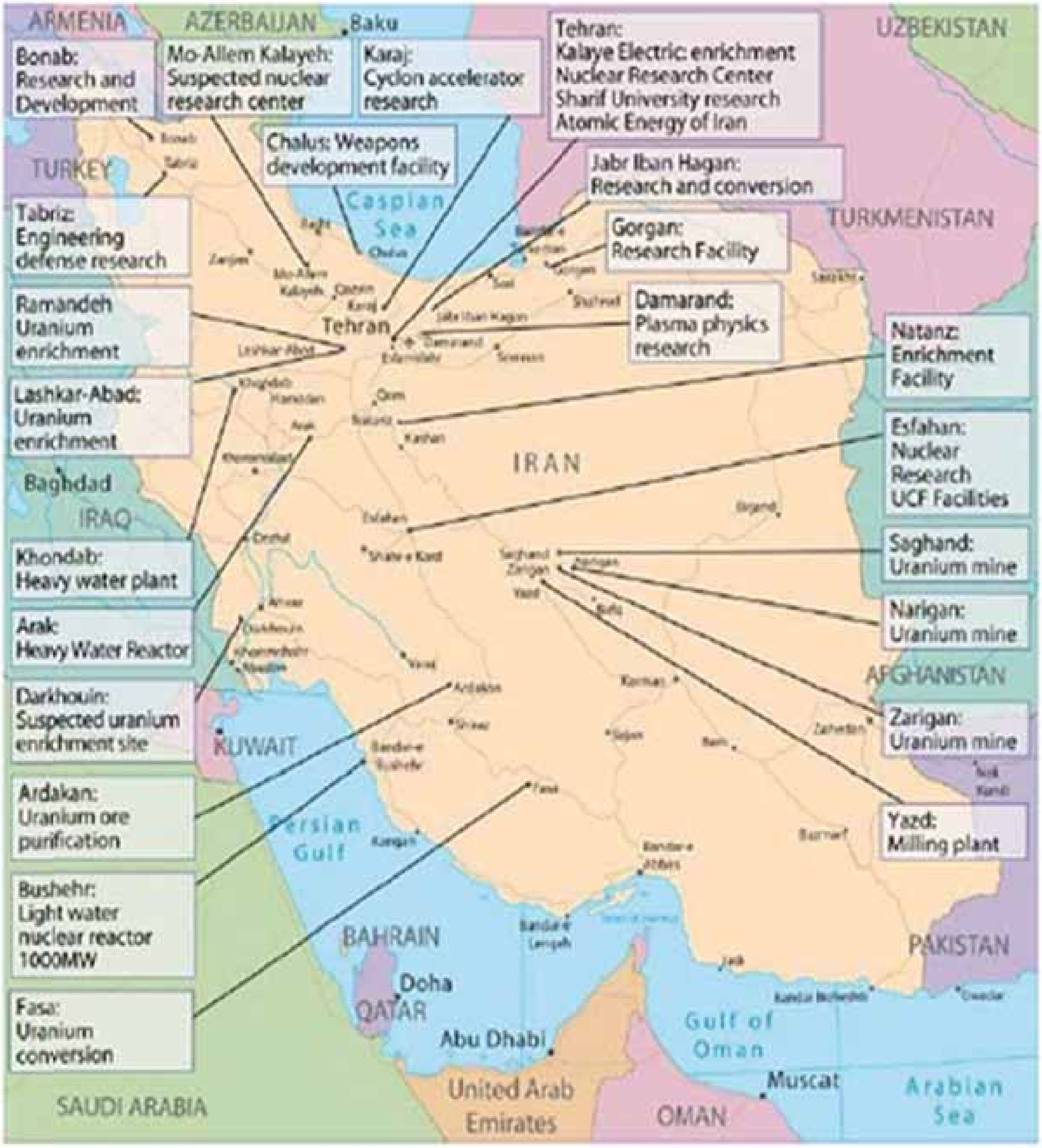
Under Iran's nuclear program, uranium is processed and according to the IAEA, has been enriched to less than 5%. Iran has faced problems with the international community, which alleges the country's enrichment process is associated with war plans and that it has already sufficient material for the construction 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.

Currently a reactor of 360 MW with Iranian technology is under construction. It was designed by Iranian experts and nuclear fuel is also manufactured in the country. The date foreseen for commissioning is 2017. This nuclear reactor (IR-360) was designed based on the 1st unit PWR NPP "Beznau" (Switzerland). Also under construction nuclear heavy water reactor of 40 MW.

Iran Nuclear Sites



Sites with nuclear activities in Iran

There have been reports that the country planned to have 20 GW nuclear capacity by 2020, but today confirmed Iran plans to build four new units, with the participation of Russia. Russia and Iran already has a preliminary to the construction of two more units at the same site of the Bushehr nuclear power plant agreement.

Japan

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
Japan	48	42.388	2	1325	13,95	1,7

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.

As 2013 drew to a close, Japan once again found itself without nuclear power as its entire fleet remained shut down pending regulatory reviews. Nevertheless, Kansai's Ohi 3 and 4 were in operation until entering scheduled outages in September. By the end of the year, 16 Japanese units had applied for permission to restart under new Nuclear Regulatory Authority regulations.

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.

Nuclear Power Plant Sendai 1 and 2

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.

After a long process Sendai nuclear power plant units 1 and 2 have draft approval to restart and generate electricity again. The final stages in Japan's new licensing regime could be completed in October.

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 it 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 2013 (TWH)	% of total energy generated in 2013
Kazakhstan	0	0	0	0	0	0

Kazakhstan has no nuclear power 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 and it has around 15 percent of the world's uranium resources) 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 isn’t 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.

Kazakhstan is the only country in Central Asia that has made a firm commitment to developing nuclear energy. It is also likely to host an international low-enriched uranium bank, construction of which could begin in 2015.
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.

In 30 May, 2014 (NucNet)- Russia and Kazakhstan have signed an agreement that could lead to them cooperating on the construction of a nuclear power station in Kazakhstan, Russia’s state nuclear corporation Rosatom has said. Rosatom also said the agreement, signed by Rosatom chief executive officer Sergei Kiriyenko and National Atomic Company of Kazakhstan (Kazatomprom) president Vladimir Schkolnik, covers possible cooperation in design, construction, commissioning, operation and decommissioning of a nuclear power station using reactors with an installed capacity of 300 megawatts to 1,200 MW. The two countries also intend to cooperate on nuclear fuel supply to the proposed facility with the possibility of fabricating the fuel, or its components, in Kazakhstan. The location for the country’s first nuclear power station is near the city of Kurchatov in eastern Kazakhstan.

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). The new units are scheduled to begin commercial operation in December 2016 and October 2017 respectively.

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.

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.

NPP Chasnupp - Pakistan (photo Rosatom)

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. There is also 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 Reactors Underconstruction, Planned and/or proposed				
Reactors	Type	Mwe gross	Construction start	Planned commercial Operation
Chashma 3	CNP-300	340	mai/11	Dec/16
Chashma 4	CNP-300	340	Dec/11	Oct/16
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 2013 (TWH)	% of total energy generated in 2013
South Korea	23	20.700	5	6,370	132,47	27,6

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 2013, these nuclear power plants produced 132.47 TWh, accounting for around 27.6 % 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.

NPP Shin-Wolsong 1 and 2 - Image AIEA

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.

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.

In 2014 South Korea has approved a plan to build two nuclear power plants, worth US$7bn, only two weeks after the country announced its intention to cut the share of nuclear in total power supply to 29% by 2035 (instead of 41% by 2030). The two reactors would have a capacity of 1,400 MW each and should be completed by late 2020, at a cost of Won 7,600bn (US$7bn).

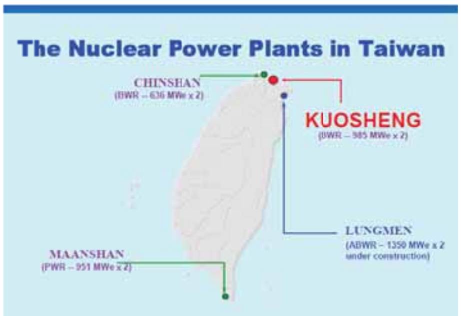
Taiwan

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
Taiwan	6	4.980	2	2.600	39,82	19.1

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 2013 was 38.82 TWh, accounting for 19,1% 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.

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.



Location of NPP in Taiwan

The Chinese also do not trust the safety of operation and stores of waste in Taiwan. A proposal and the invitation were made so that the two countries work together on this issue.
Taiwan national power utility Taipower has completed pre-operational tests at its Lungmen-1 nuclear power plant but the plant is not expected to enter commercial operation before 2017 at the earliest.

Taiwanese Plants In Operation:

Units	type	MWe gross	MWe net	Start up*	Licensed to
Chinshan 1	BWR	636	604	1978	2018
Chinshan 2	BWR	636	604	1979	2019
Kuosheng 1	BWR	985	948	1981	2021
Kuosheng 2	BWR	985	948	1983	2023
Maanshan 1	PWR	951	900	1984	2024
Maanshan 2	PWR	951	923	1985	2025
Total (6)		**4927 MWe net**			

Construction of two 1,350 MW Advanced Boiling Water Reactors (ABWRs) started in Lungmen in 1999: the two reactors were expected to be commissioned in 2006 and 2007 but commercial operations were delayed due to political, legal and regulatory problems.

In April 2014 the Taiwanese government announced the decision to halt the remaining construction of the Lungmen power plant. The first reactor will be sealed after the completion of safety checks, and construction of the second reactor will be halted. A final decision may be subject to a national referendum

Vietnam

Country	Reactors in operation	installed capacity (MW)	Reactors under construction	capacity under construction (MW)	generated energy 2013 (TWH)	% of total energy generated in 2013
Vietnam	0	0	0	0	0	0

Over the past 20 years, energy production in Vietnam increased more than 10 times, growing at an average rate of 13% / year, from 12 TWh in 1994 to about 130 TWh in 2013. Meanwhile, energy consumption per capita increased, reaching 1,445 kWh/cap, i.e. 8 times the average volume of 1994 (175 kWh). As a result the Vietnamese prime minister said, in May 2010, the intention of building eight reactors.

Vietnam - Planned and Proposed Nuclear Power Reactors to 2030

Location	Plant (province)	Type	MWe nominal	Start construction	Operation
Phuoc Dinh	Ninh Thuan 1-1	VVER-1000/428	1060	2017 or 2018	2023
Phuoc Dinh	Ninh Thuan 1-2	VVER-1000/428	1060	2018 or 2019	2024
Phuoc Dinh	Ninh Thuan 1-3	VVER-1000	1000		?
Phuoc Dinh	Ninh Thuan 1-4	VVER-1000	1000		?
Vinh Hai	Ninh Thuan 2-1	Japanese Gen III or Atmea1	850-1150	Dec 2015, delayed	2024?
Vinh Hai	Ninh Thuan 2-2	Japanese Gen III or Atmea1	850-1150	2016, delayed	2025?
Vinh Hai	Ninh Thuan 2-3	Japanese Gen III or Atmea1	850-1150		?
Vinh Hai	Ninh Thuan 2-4	Japanese Gen III or Atmea1	850-1150		?
Central		APR-1400?	1350		2028
Central		APR-1400?	1350		2029
Total planned (4)			4000		
Total proposed by 2030			6700		

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 2018.

Central 2 (Ninh Thuan Plant 2, with two reactors) will be installed in Vinh Hai Commune, Ninh Hai district, however there is no signed contract. There is an agreement with Japan for its construction; with expected operation in 2024.

In 2012 Korea and Vietnam signed an agreement for the preparation of feasibility studies for construction of the Central Third in the country with two more reactors Model and Korean design.

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

Bangladesh

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.

In April 2014 the third contract with Rosatom which foresees the creation of a database of construction on the site of the nuclear plant and the organization of the site to the placement of the first concrete construction of the reactors was signed in 2020.

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

Indonesia

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.

The Japan Atomic Energy Agency has reached an agreement with Indonesia's national Atomic Energy Agency to offer Indonesia technical help on the construction of multiple high-temperature gas-cooled reactors, or HTGRs, JAEA said August 5, 2014.

The Indonesian agency published plans in June for the construction of two 1,000-MW LWRs on two of three candidate islands — Java, Madura and Bali — starting in 2027, and for two 1,000-MW LWRs in Sumatra beginning 2031, according to JAEA.

The Indonesian also plans to begin operating by 2020 a demonstration HTGR that has a generating capacity of 3 MW to 10 MW, JAEA said. It could take four years to construct the unit. Initial cooperation will involve the exchange of information on the High-Temperature Engineering Test Reactor, or HTTR, at Oarai, near the village of Tokai.

Malaysia

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.

Philippines

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

Thailand

The Russian state-owned Rosatom and the Institute of Nuclear Technology of Thailand signed during the 58th Conference of the IAEA in September 2014, a memorandum on the use of atomic energy for peaceful purposes. The parties also plan to develop cooperation in the field of fundamental and applied studies, radioisotopes, nuclear safety and nuclear waste treatment, education and preparation of scientific and technical personnel services.

E - Australia

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 do operate the Opal research reactor near Sydney.

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)

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. Despite its uranium production, Australia will not develop nuclear power in the middle term. The country has an overcapacity in generation, expected to last until 2023-2024.

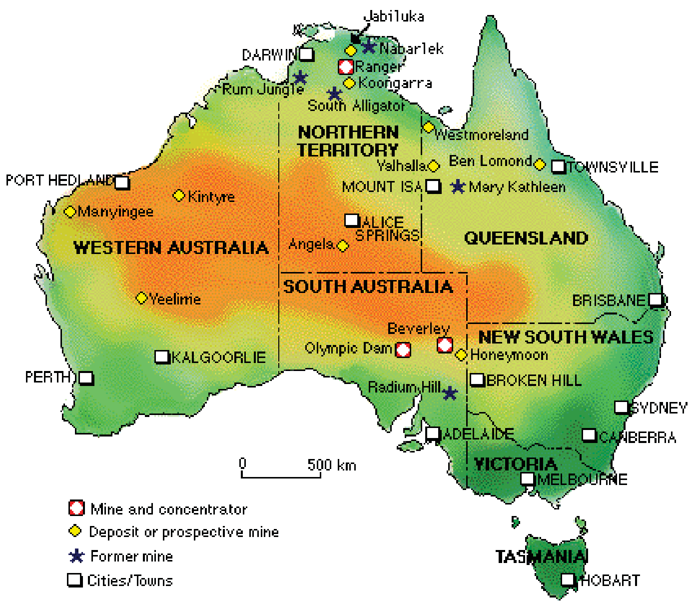
The Open Pool Australian Light-water Reactor (OPAL) is a multipurpose installation, particularly oriented towards radioisotope production.

It is one of the most powerful and complex research reactors in the world and it represent the largest cash sale export of a turnkey state-of-the-art technology plant ever made by an Argentine company. It will supply radioisotopes to Australia and other countries, and it will offer silicon irradiation services to the microelectronic industry.

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.

OPAL Reactor Building (photo Lucas Heiths – Australia Front View)

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 2014)*

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 – 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 – China

The United States (EXELON Company) and China (CNNC) have signed an agreement 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 – 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 – 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 – 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 – 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

A US-Vietnam agreement on civil nuclear cooperation came into force in

September 2014. The agreement sets the terms for nuclear trade, exchange in research and technology between the two countries and was signed in March 2010, as a memorandum of understanding. This will increase cooperation with the United States and will give to Vietnam access to nuclear fuel. It is expected in the future construction of the first power reactor in Vietnam.

United States – Ukraine

In june 2014 - Ukraine's state nuclear operator Energoatom and Holtec International (American Co.) have signed an agreement for the construction of a centralised repository for spent nuclear fuel at the Chernobyl nuclear power station. Completion of the facility is scheduled for the end of 2017. The facility will hold up to 17,000 spent nuclear fuel elements from three nuclear power stations: Khmelnitski, Rovno and South Ukraine. The Khmelnitski nuclear station has two commercially operational reactors and two under construction. Rovno has four reactors and South Ukraine three. Ukraine's fourth commercial nuclear station, the six-unit Zaporozhye, has its own spent fuel storage facility, commissioned in 2001.

Russia and Others:

Russia-Argentina

The presidents of Russia and Argentina signed on 12 July 2014 agreements for cooperation in peaceful use of nuclear energy and announced the signing of very important agreements in the nuclear area for power generation. She said it was an "excellent working meeting". Putin described as "strategic" relationship between the two countries and thanked "the opportunity to discuss the strategy of mutual interest"

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 – 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 – 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 – 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 – 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 – Iran

Atomenergoproekt (NIAEP), a subsidiary of the Russian State Company Atomstroiexport and Production and Development of Nuclear Energy Company of Iran (NPPD) signed an agreement in Moscow (on 11.11.2014) for the construction of two new reactors nuclear power plant in Buchehr, with the possibility of constructing two other reactors in sites to be define in future. In September 2013, Iran and Russia had signed a series of cooperation agreements that will allow both countries to establish a new strategic partnership.

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 – 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 – 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 – 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 – 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 – 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.

Russian - Saudi Arabian

Russian and Saudi Arabian officials have approved the draft of an agreement on cooperation in nuclear energy, Rosatom announced in a statement June 18, 2014. Atomic and Renewable Energy is developing and implementing Saudi Arabia's nuclear energy development program. The country is considering construction of as many as 16 power reactors as part of the program, Saudi officials have said.

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 South Africa

On September 22, 2014 South Africa and Russia signed a strategic partnership agreement on nuclear energy collaboration, according to Russian state nuclear company Rosatom, but an official in the South African nuclear program emphasized that Russian technology was only one of the options being considered. The agreement lays the foundation for large scale nuclear power plant procurement and development program by South Africa based on the construction in South Africa of Russian VVER reactors with a total installed capacity of up to 9.6 GW (up to eight nuclear Units).

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 – Thailand

The Russian state-owned Rosatom and the Institute of Nuclear Technology of Thailand signed during the 58th Conference of the IAEA in September 2014, a memorandum on the use of atomic energy for peaceful purposes. The parties also plan to develop cooperation in the field of fundamental and applied studies, radioisotopes, nuclear safety and nuclear waste treatment, education and preparation of scientific and technical personnel services.

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 – Vietnam

In May 2010 an intergovernmental agreement was signed with Russia, for nuclear cooperation in areas such as siting, design, construction and operation of power and research nuclear reactors, water desalination plants, and elementary particle accelerators. Other areas covered included fuel supply and wastes – Russia will manage wastes and decommissioning.

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 – 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).

Russia – United Kingdom

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

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.

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 tons of U3O8; on Semizbay deposits in Akmolinskaya (annual production capacity estimated at 500 tons of U^3O^8) and on Zhalpak deposits, annual production capacity estimated at 750 tons 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 UF6 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 UF6.
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 and Others

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 – 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.
3- China and Argentina signed agreements July 18, 2014 relating to construction of a PHWR unit in Argentina. China National Nuclear Corp., or CNNC, will be responsible for assisting Nucleoelectrica by providing Chinese goods and services under long-term financing.

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 – 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.

China – Italia

During a visit by Italian Prime Minister Matteo Renzi to China in 12-13 June, 2014 two agreements were signed:

1- China General Nuclear Power Group, or CGN, and Sogin –a italian nuclear-waste processing company have signed a memorandum of understanding on nuclear waste management. The two groups will seek to strengthen cooperation on environmental remediation of nuclear facilities and safe management of radioactive waste. CGN and Sogin could cooperate in related environmental decontamination and radioactive waste management work in Europe, Italy and China, particularly in the decommissioning of nuclear facilities and the management of radioactive waste.

2- China National Nuclear Corp., or CNNC, and Italian electricity group Enel have signed a memorandum of understanding to strengthen nuclear power cooperation, the Chinese company said in a statement June 13, 2014. The two companies will begin cooperation on nuclear plant construction, plant operation, fuel supply, environmental remediation of nuclear facilities and nuclear waste management, the statement said. CNNC is one of the three major nuclear power companies in China. Enel is the second-largest utility in Europe by market capitalization.

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 – Romania

December 2013 - Romania's Nuclearelectrica and China General Nuclear Power Group signed an agreement in November that could lead to the construction of two additional Candu units at the Cernavoda plant, although no details on the agreement were provided

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 – South Africa

1-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.
2- China and South Africa have signed an intergovernmental framework agreement on November 7Th, 2014 to deepen nuclear cooperation that paves the way for possible use of Chinese nuclear technology in South Africa. In this new agreement the countries initiate the preparatory phase for a possible utilization of Chinese nuclear technology in South Africa.

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.

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 Eletrobras 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.

Jordan – United Kingdom

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 – Brasil

On January31, 2011 Argentina and Brazil, through its regulatory agencies CNEA and

CNEN signed cooperation agreement for the development of multipurpose research reactors RA-10 and RMB.

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.

Brazil – Germany

The German Bundestag - Chamber of Deputies of Germany, decided on 06.11.2014, by the continuation of the cooperation agreement with Brazil in the area of nuclear energy. The agreement, signed in 1975, is automatically renewed every five years if none of the countries involved is opposed position at least one year prior to the date of renovation (2015).

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 which 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 – Italy

Westinghouse has agreed to buy Mangiarotti, an Italian pressure vessel manufacturer that makes dozens of key components for the company's AP1000 reactor. The purchase will allow Westinghouse to expand into the oil and gas businesses. (2014, July)

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 – 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

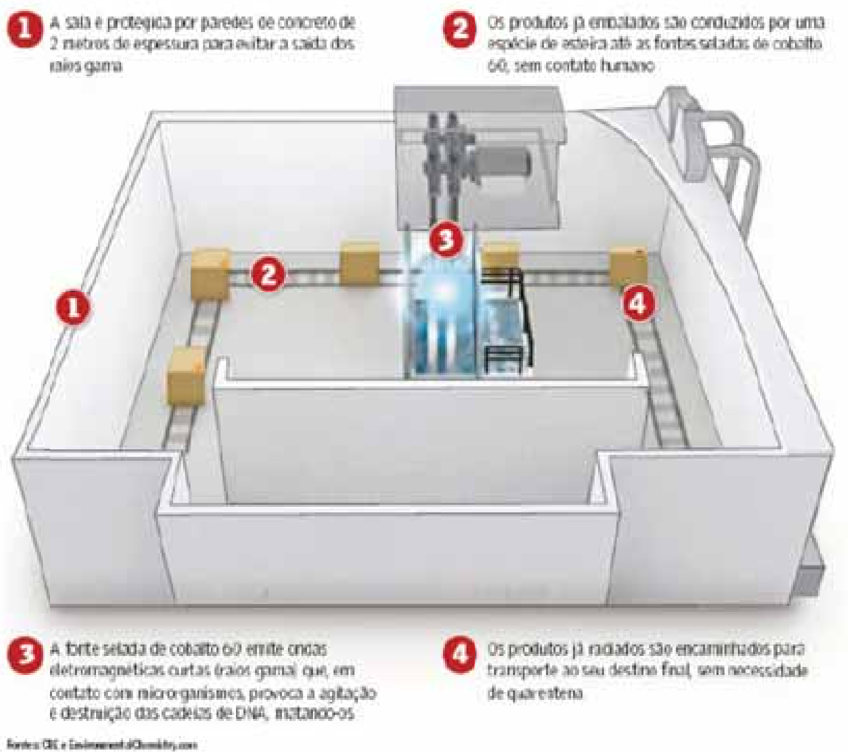
Product	Without Ionization	With Ionization
Garlic	4 months	10 months
rice	1 year	3 year
banana	15 days	45 days
potato	1 month	6 month
onion	2 months	6 months
flour	6 months	2 years
fish	5 days	30 days
chiken	7 days	31 days
vegetables	5 days	18 days
mango	7 days	21 days
corn	1 year	3 year
strawberry	3 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.



Some Details of Gamma Ray sterilization

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,

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.

Molybdenum (^{99} Mo) Producers' reactors in the World

Country	Reactor Name	Age in years	Scheduled shutdown	supplied demand
Canada	NRU	55	out/16	40
Belgium	BR2	51		
South Africa	Safari-1	47		
Netherlands	HFR	51	2018	90 a 95%
France	Osiris	46	2015(?)	
Argentina	RA-3	45		
Australia	OPAL	5		

Previsão de crise mundial de abastecimento a partir de 2015, com impacto direto no Brasil em 2016

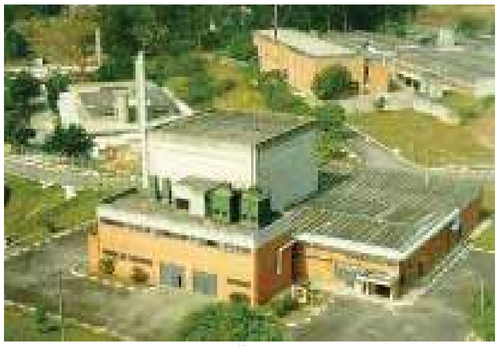
The technetium-99 (^{99m}Tc) is the most widely used radiopharmaceuticals in the world. More than 80% of nuclear medicine procedures in the world, mainly in scintigraphy using ^{99m} Tc is obtained from the molybdenum-99 (99Mo). This radioisotope has more than 90% of their production done by only seven reactors worldwide. In addition to concentrating the supply of the product, six of these reactors are over 45 years of operation, which means it will no longer operate in a very short time, being the only exception is the Australian Opal reactor, installed just five years ago.

A solution to the problem would be 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 (set to be in operation in 2019). Its implementation could meet this demand and that of other industries in Brazil's industrial needs, seeing that, besides radioisotope production, essential for diagnosis and therapy of various diseases, 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, 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.


IEA-R1m -CNEN/IPEN -São Paulo- Brazil


IPEN/MB-01 - São Paulo - Brazil

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.

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.

Reactor OPAL, in Australia
Reference for RMB

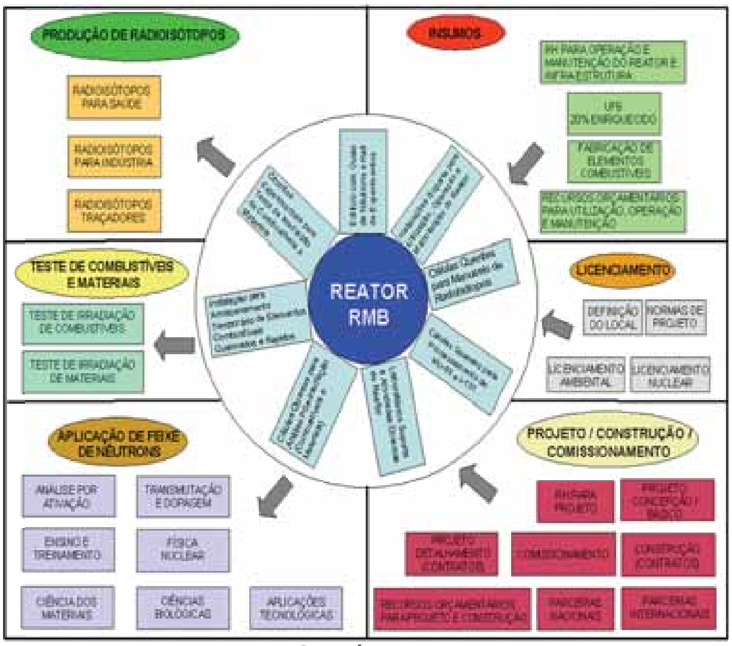


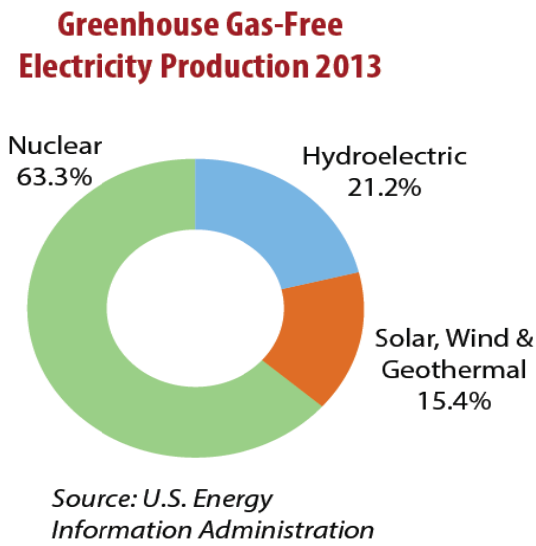
Image - Prof. José Augusto Perrota

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.

VII – 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.



Nuclear energy is by far the largest clean-air energy source and the only one that can produce large amounts of electricity around the clock. In 2013, more than 63% of the non-pollutant energy generated in the United States came from nuclear power, with a share of only 19,3% 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 economic, social, and environmental risks of unabated climate change are immense. They threaten to roll back the fruits of decades of growth and development, undermine prosperity, and jeopardize countries' ability to achieve even the most basic socio-economic development goals in the future, including the eradication of poverty and continued economic growth. These risks affect all developed and developing countries alike.

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 - CO2 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 security and wealth factor for countries and nuclear energy is a source of large, operating on the basis of the systems, producing locally emission-free greenhouse energy to meet all those conditions.

There is no prospect of winning the fight against climate change if countries fail on poverty eradication or if countries do not succeed in raising the living standards of their people. Addressing climate change requires deep emission reductions of all greenhouse gases (GHGs), including the deep decarbonizing of energy systems. To be successful, this transition must ensure that socio-economic development needs are met within the constraints of very low emissions. 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.

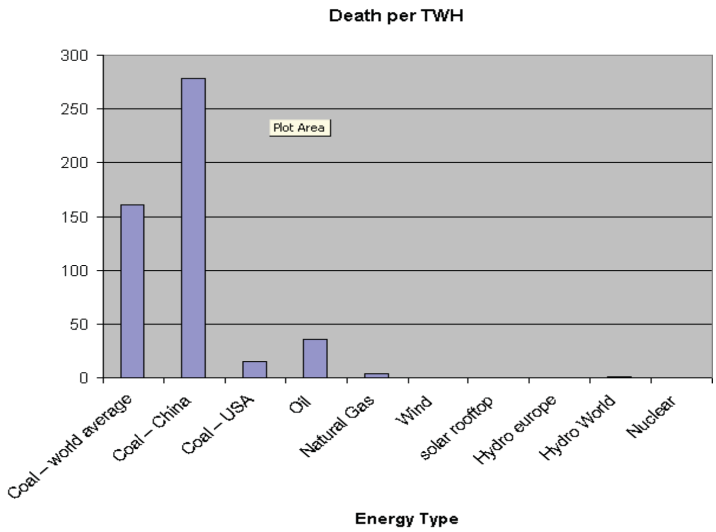
Energy supply security is intrinsically related to geopolitical preferences, technology strategies selected and the social policy orientations defined by the several countries. Combining the conditions associated with borders, neighborhood, continental location and domestic resources leads to the wide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

It is important to increase security whenever possible, and nuclear plants are updated constantly to do just that. There was never even a death due to operation of the whole cycle of nuclear power in the USA. The nuclear power industry has literally one of the best safety ratings in comparison to any other industry worldwide.

Per kWh produced, fewer people died in the life cycle of nuclear power than the life cycle of solar energy, and both are very smaller than accidents in generation of energy from fossil fuels; even in hydroelectric power plants deaths count rises much when the dams break.

Why people are reluctant to get on the plane due to fear for their safety while driving cars every day? The probability of dying in a car is 4 times greater than dying in a plane. All of this has relation with the perception of risk, and we, as humans, are very bad at estimating the dangers in our everyday lives.

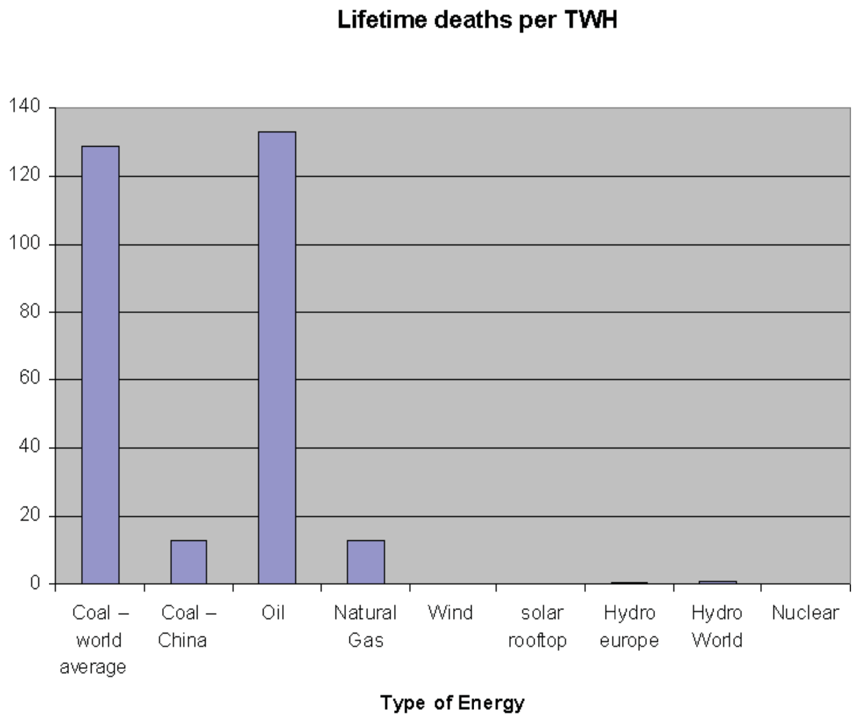


Public safety should be the number one concern, but cannot be dogmatic. When you put up wind farms and solar plants they need gas in parallel to replace the lack of energy production when there is no wind or sun. This system puts more carbon into the atmosphere and generates more loss of life than a nuclear power plant producing the same energy. Safety of the public needs to be the number one concern, but it can't be dogmatic. When you put up wind and solar farms they need accompanying gas plants to replace the slack to the grid when they aren't producing. That system puts more carbon into the atmosphere and generates more loss of life than a nuclear plant producing the same power.

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.

The challenges associated with developing and carrying out an effective public consultation campaign is compounded by the depth of public mistrust and misunderstandings concerning radiation, nuclear power plants and uranium mining. An effective public consultation is required to gain public acceptance of any nuclear activity since uranium mining until decommissioning of the plant.

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. The next-generation of nuclear energy is an essential part of the solution to protect future generations.

VIII – Fuel

Uranium

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.

The main use of uranium in the civilian sector is to fuel nuclear power plants. **One kilogram** of uranium-235 can theoretically produce about 20 terajoules of energy (2×10^{13} joules), assuming complete fission; as much energy as **1500 tons** of coal.

Yellowcake production and Uranium ore - INB photos

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*".

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

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.

Production from mines (tonnes U) - WNA									
Country	2005	2006	2007	2008	2009	2010	2011	2012	2013
Kazakhstan	4357	5279	6637	8521	14020	17803	19451	21317	22451
Canada	11628	9862	9476	9000	10173	9783	9145	8999	9331
Australia	9516	7593	8611	8430	7982	5900	5983	6991	6350
Niger (est)	3093	3434	3153	3032	3243	4198	4351	4667	4518
Namibia	3147	3067	2879	4366	4626	4496	3258	4495	4323
Russia	3431	3262	3413	3521	3564	3562	2993	2872	3135
Uzbekistan	2300	2260	2320	2338	2429	2400	2500	2400	2400
USA	1039	1672	1654	1430	1453	1660	1537	1596	1792
China (est)	750	750	712	769	750	827	885	1500	1500
Malawi					104	670	846	1101	1132
Ukraine (est)	800	800	846	800	840	850	890	960	922
South Africa	674	534	539	655	563	583	582	465	531
India (est)	230	177	270	271	290	400	400	385	385
Brazil	110	190	299	330	345	148	265	231	231
Czech Republic	408	359	306	263	258	254	229	228	215
Romania (est)	90	90	77	77	75	77	77	90	77
Germany	94	65	41	0	0	8	51	50	45
Pakistan (est)	45	45	45	45	50	45	45	45	27
France	7	5	4	5	8	7	6	3	5
total world	**41 719**	**39 444**	**41 282**	**43 764**	**50 772**	**53 671**	**53 493**	**58 394**	**59,37**
tonnes U3O8	49 199	46 516	48 683	51 611	59 875	63 295	63 084	68 864	70,015
percentage of world demand*	65%	63%	64%	68%	78%	78%	85%	86%	92%

World production continuing to grow in 2013, with Kazakhstan being again the biggest producer. In 2013 the greatest producing companies were Kazatomprom (Kazakhstan); Cameco (Canada), Rio Tinto (Australia), Areva (France) 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.

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	10548	18
Total	58394	100

Known Recoverable Resources of Uranium 2013 - Source : WNA

Known Recoverable Resources of Uranium 2013		
Country	tonnes U	percentage of world
Australia	1,706,100	29%
Kazakhstan	679,300	12%
Russian Fed	505,900	9%
Canada	493,900	8%
Niger	404,900	7%
Namibia	382,800	6%
South Africa	338,100	6%
Brazil	276,100	5%
USA	207,400	4%
China	199,100	4%
Mongolia	141,500	2%
Ukraine	117,700	2%
Uzbekistan	91,300	2%
Botswana	68,800	1%
Tanzania	58,500	1%
Jordan	33,800	1%
Other	191,500	3%
World total	5,902,500	

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 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.

According to consultant UxC, Asia should lead such capacity increase and overtake North America, currently the greatest consumer. The world consumption of U_3O_8 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.

Nuclear fuel pellets

Currently, besides Brazil, only ten countries in the world hold uranium enrichment technology: Germany, China, United States, France, Holland, India, Iran, Japan, Pakistan and the UK. None of these countries sell or transfer that knowledge or technology. 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.

WNA- August 2014

Country	NUCLEAR ELECTRICITY GENERATION		REACTORS OPERABLE ago/14		REACTORS UNDER CONSTRUCTION ago/14		ON ORDER or PLANNED ago/14		PROPOSED ago/14		URANIUM REQUIRED
	billion kWh	% e	No.	MWe	No.	MWe	No.	MWe	No.	MWe	tonnes U
Argentina	5.7	4.4	3	1627	1	27	0	0	3	1600	213
Armenia	2.2	29.2	1	376	0	0	1	1060			87
Bangladesh	0	0	0	0	0	0	2	2000	0	0	0
Belarus	0	0	0	0	2	2400	0	0	2	2400	0
Belgium	40.6	52.0	7	5943	0	0	0	0	0	0	1017
Brazil	13.8	2.8	2	1901	1	1405	0	0	4	4000	325
Bulgaria	13.3	30.7	2	1906	0	0	1	950	0	0	321
Canada	94.3	16.0	19	13553	0	0	2	1500	3	3800	1784
Chile	0	0	0	0	0	0	0	0	4	4400	0
China	104.8	2.1	20	17055	29	33035	59	63735	118	122000	6296
Czech Republic	29.0	35.9	6	3766	0	0	2	2400	1	1200	563
Egypt	0	0	0	0	0	0	1	1000	1	1000	0
Finland	22.7	33.3	4	2741	1	1700	0	0	2	2700	480
France	405.9	73.3	58	63130	1	1720	1	1720	1	1100	9927
Germany	92.1	15.4	9	12003	0	0	0	0	0	0	1889
Hungary	14.5	50.7	4	1889	0	0	2	2400	0	0	357
India	30.0	3.4	21	5302	6	4300	22	21300	35	40000	913
Indonesia	0	0	0	0	0	0	1	30	4	4000	0
Iran	3.9	1.5	1	915	0	0	1	1000	1	300	174
Israel	0	0	0	0	0	0	0	0	1	1200	0
Italy	0	0	0	0	0	0	0	0	0	0	0
Japan	13.9	1.7	48	42569	3	3036	9	12947	3	4145	2119
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)	132.5	27.6	23	20656	5	6870	6	8730	0	0	5022
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	11.4	4.6	2	1600	0	0	0	0	2	2000	277
Netherlands	2.7	2.8	1	485	0	0	0	0	1	1000	103
Pakistan	4.4	4.4	3	725	2	680	0	0	2	2000	99
Poland	0	0	0	0	0	0	6	6000	0	0	0
Romania	10.7	19.8	2	1310	0	0	2	1440	1	655	179
Russia	161.8	17.5	33	24253	10	9160	31	32780	18	16000	5456
Saudi Arabia	0	0	0	0	0	0	0	0	16	17000	0
Slovakia	14.6	51.7	4	1816	2	942	0	0	1	1200	392
Slovenia	5.0	33.6	1	696	0	0	0	0	1	1000	137
South Africa	13.6	5.7	2	1830	0	0	0	0	6	9600	305
Spain	54.3	19.7	7	7002	0	0	0	0	0	0	1274
Sweden	63.7	42.7	10	9508	0	0	0	0	0	0	1516
Switzerland	25.0	36.4	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	78.2	43.6	15	13168	0	0	2	1900	11	12000	2359
UAE	0	0	0	0	2	2800	2	2800	10	14400	0
United Kingdom	64.1	18.3	16	10038	0	0	4	6680	7	8920	1738
USA	790.2	19.4	100	99361	5	6018	5	6063	17	26000	18816
Vietnam	0	0	0	0	0	0	4	4000	6	6700	0
World	**2359**		**435**	**375,303**	**72**	**76,793**	**174**	**190,185**	**299**	**329,37**	**65,908**

Uranium Demand

In June 2014, 437 commercial nuclear reactors with a generating capacity of 373,000 MWe needed about 66,000 tons of uranium.

In 2035, the World Nuclear Association estimates that uranium demand will be from 97 645 tons of uranium (to generating 540,000 Mwe, the case of low demand), and 136,385 tons of uranium (to generate 746,000 MWe, the high case demand). East Asia, especially China, must have the highest growth, with the implementation between 100,000 and 150,000 MWe by 2035.

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.

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).

Countries with strong and growing demand for energy, such as China and India, are the strongest candidates for the development of Thorium technology. India, with vast reserves of this ore, wants 25% of its energy production in the next decade will come from thorium (today is 3%) while China makes its first powered thorium reactor to become operational in 2015. in March 2014, China announced that it is accelerating its research on the so-called molten salt reactors that can use thorium. If successful, it would create a cheaper, more efficient and safer form of nuclear power, with nuclear waste which are smaller than uranium based on today's technology.

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).

Plutonium

It is a radioactive actinide metal whose isotope, plutonium-239, is one of the three primary fissile isotopes (uranium-233 and uranium-235 are the other two); plutonium-241 is also highly fissile.

Fission of a kilogram of plutonium-239 can produce an explosion equivalent to 21,000 tons of TNT (88,000 GJ). It is this energy that makes plutonium-239 useful in nuclear weapons and reactors.

Plutonium-239 is the most important isotope of plutonium, with a half-life of 24,100 years. It can sustain a nuclear chain reaction, leading to applications in nuclear reactors and nuclear weapons. Pu-239 is synthesized by irradiating uranium-238 with neutrons in a nuclear reactor, then recovered via nuclear reprocessing of the fuel. It is a fissile isotope which is the second most used nuclear fuel in nuclear reactors after U-235, and the most used fuel in the fission portion of nuclear weapons.

Plutonium can form alloys and intermediate compounds with most other metals:

- **Plutonium-gallium** (Pu-Ga) - Its main use is in pits of implosion nuclear weapons
- **Plutonium-aluminium** is an alternative to the Pu-Ga alloy can be also used as a component of nuclear fuel.
- **Plutonium-gallium-cobalt** alloy ($PuCoGa_5$) is an unconventional superconductor, showing superconductivity at special conditions
- **Plutonium-zirconium** alloy can be used as nuclear fuel.
- **Plutonium-cerium** and **plutonium-cerium-cobalt** alloys are used as nuclear fuels.
- **Plutonium-uranium**, with about 15–30 mol.% plutonium, can be used as a nuclear fuel for fast breeder reactors.
- **Plutonium-uranium-titanium** and **plutonium-uranium-zirconium** were investigated for use as nuclear fuels.
- **Plutonium-uranium-molybdenum** has the best corrosion resistance, forming a protective film of oxides, but titanium and zirconium are preferred for physics reasons.
- **Thorium-uranium-plutonium** was investigated as a nuclear fuel for fast breeder reactors.

MOX fuel

Mixed oxide fuel, commonly referred to as MOX fuel, is nuclear fuel that contains more than one oxide of fissile material, usually consisting of plutonium blended with natural uranium, reprocessed uranium, or depleted uranium.

MOX fuel is an alternative to the low-enriched uranium (LEU) fuel used in the light water reactors that predominate nuclear power generation. For example, a mixture of 7% plutonium and 93% natural uranium reacts similarly, although not identically, to LEU fuel. Although MOX fuel can be used in thermal reactors to provide energy, efficient burning of plutonium in MOX can only be achieved in fast reactors.

One attraction of MOX fuel is that it is a way of utilizing surplus weapons-grade plutonium, an alternative to storage of surplus plutonium, which would need to be secured against the risk of theft for use in nuclear weapons. On the other hand, some studies warned that normalizing the global commercial use of MOX fuel and the associated expansion of nuclear reprocessing will increase, rather than reduce, the risk of nuclear proliferation, by encouraging increased separation of plutonium from spent fuel in the civil nuclear fuel cycle

About 40 reactors in Europe – in Belgium, Switzerland, Germany, the Netherlands and France – are licensed to use MOX fuel, and more than 30 are doing so. In Japan about 10 reactors are licensed to use it and several have done so.

In Russia, there are no commercial reactors using MOX fuel but the BN-800 Beloyarsk-4 fast neutron reactor, where fuel loading was completed in July 2014 and commercial operation is due within months, will use MOX fuel.

A commercial MOX fuel fabrication facility was established at Zheleznogorsk, Russia in 2014.

IX – 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 tons (of heavy metal).

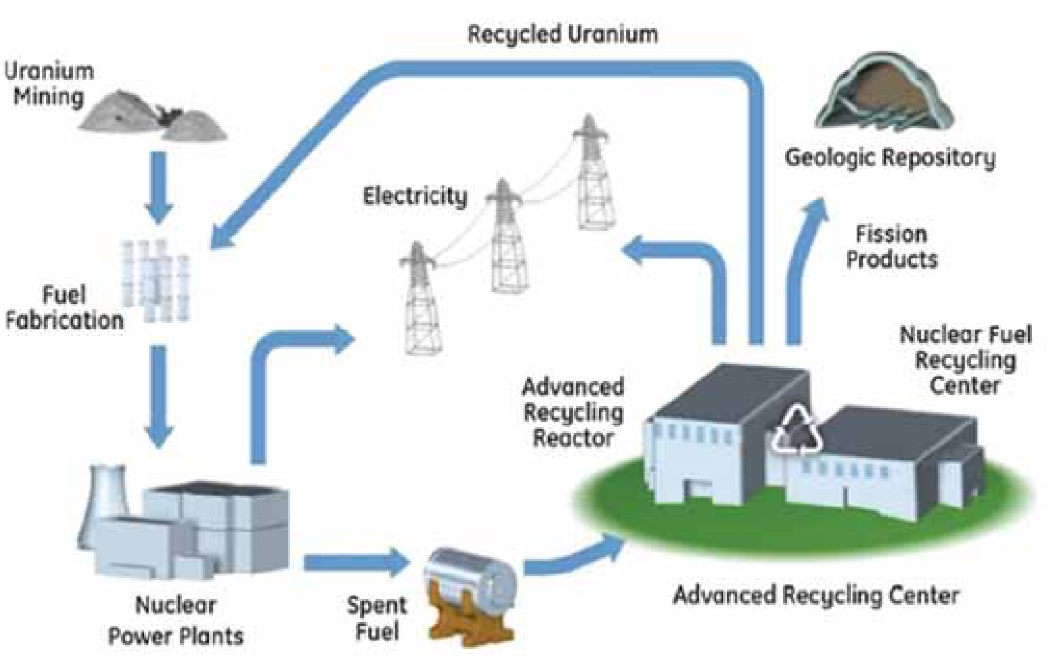
Some countries view spent fuel as a material to be stored in final repositories for high level radioactive waste. Other countries consider this material an energy resource to be reprocessed and reused.

Reprocessing Plant - Sellafield - Cumbria – United Kingdom

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.

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. 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.



Nuclear Fuel cycle

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.

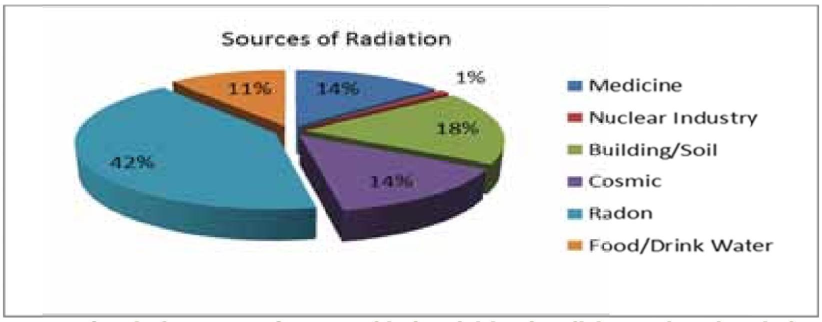
The development of innovative solutions such as the Myrrha project (Multi-Purpose Hybrid Research Reactor for High-Tech Applications) in Belgium offers other possibilities for nuclear waste treatment such as transmutation. Although a large capacity plant is still a long way off, a pilot project (at a 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

Radioactivity is a natural phenomenon and natural sources of radiation are features of the environment. Radiation and radioactive substances have many beneficial applications, ranging from power generation to uses in medicine, industry and agriculture.

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.

As with many things in nature, radiation can be good or bad, depending on the amount.



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

The radiation risks to workers and the public and to the environment that may arise from these applications have to be assessed and, if necessary, controlled.
Activities such as the medical uses of radiation, the operation of nuclear installations, the production, transport and use of radioactive material, and the management of radioactive waste must therefore be subject to standards of safety.

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

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.

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.
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:

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

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.

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.

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

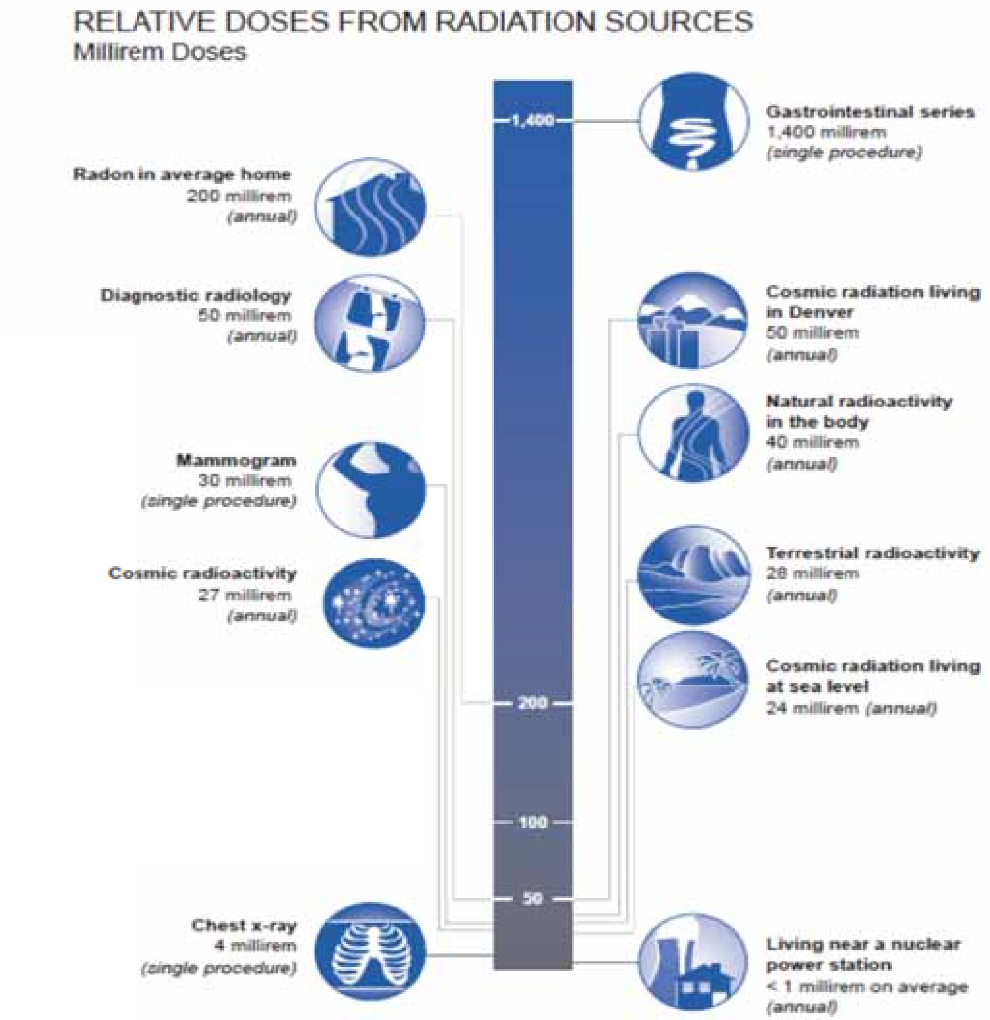
The public's lack of knowledge on this subject and the large number of measurement units give rise to much confusion and disinformation, often purposeful, and can cause fear and anxiety in lay people.

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:

In Brazil, in the locality of Guarapari, Espírito Santo, a dose of 200mSv/year is normal due to monazite sands on beaches.



From EPA – Radiations: Risks and Realities

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.
Examples of radiation doses per year of continuous exposure:

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

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.

Radioactivity in some materials natural or not	
	Fonte: WNA
1 adult human being (65 Bq/kg)	4.500 Bq
1 kg coffee	1.000 Bq
1 kg superphosphate fertilizer	5.000 Bq
The air of a house 100 m^2 in Australia (randon)	3.000 Bq
The air of a house 100 m^2 inEuropa (radon)	até 30.000 Bq
1 smoke detector (with americium)	30.000 Bq
Radioisotopes for medical diagnosis	70 milhões Bq
Sources of Radioisotopes medical therapies	100Trilhões Bq (100 TBq)
1 kg of nuclear waste (vitrified) high activity with 50 year old	10 Trilhões Bq (= 10 TBq)
1light exit signal (1970)	1 Trilhões Bq (1 TBq)
1 kg de uranium	25 milhões Bq
1 kg of uranium ore (Canada, 15%)	25 milhões Bq
1 kg uranium ore (Austrália, 0.3%)	500.000 Bq
1 kgof low activity nuclear waste	1 milhão Bq
1 kg of coal ash	2.000 Bq

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

Above-ground nuclear tests by the Soviet Union and the United States in the 1950s and early 1960s and by France into the 1970s and 1980s spread a significant amount of fallout from uranium daughter isotopes around the world.

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.

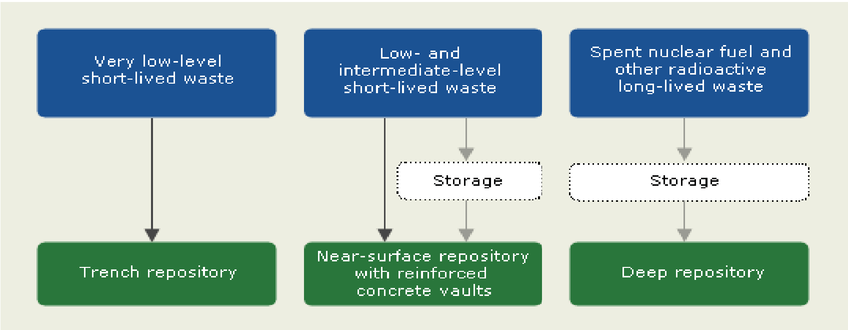
In the internal market there are companies that have developed technologies that are already licensed for use in the nuclear fuel for storage and also used for transportation.

Dry storage Example (Holtec International Co)

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.



Final Storage for low and intermediate levels in World

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.
In as much 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.

This makes it possible to carefully develop plans and policies for closing of the nuclear fuel cycle, including final waste disposal. Development of nuclear energy presupposes nuclear industry's commitment to waste management.

In most countries repositories or at least storage facilities for low-level wastes and intermediate-level wastes are operating.

Waste management for used fuel and HLW from nuclear power reactors - WNA Sept 2014		
Country	**Policy**	**Facilities and progress towards final repositories**
Belgium	Reprocessing	Central waste storage at Dessel
		Underground laboratory established 1984 at Mol
		Construction of repository to begin about 2035
Canada	Direct disposal	Nuclear Waste Management Organisation set up 2002
		Deep geological repository confirmed as policy, retrievable
		Repository site search from 2009, planned for use 2025
China	Reprocessing	Central used fuel storage at LanZhou
		Repository site selection to be completed by 2020
		Underground research laboratory from 2020, disposal from 2050
Finland	Direct disposal	Program start 1983, two used fuel storages in operation
		Posiva Oy set up 1995 to implement deep geological disposal
		Underground research laboratory Onkalo under construction
		Repository planned from this, near Olkiluoto, open in 2020
France	Reprocessing	Underground rock laboratories in clay and granite
		Parliamentary confirmation in 2006 of deep geological disposal, containers to be retrievable and policy "reversible"
		Bure clay deposit is likely repository site to be licensed 2015, operating 2025
Germany	Reprocessing but moving to direct disposal	Repository planning started 1973
		Used fuel storage at Ahaus and Gorleben salt dome
		Geological repository may be operational at Gorleben after 2025
India	Reprocessing	Research on deep geological disposal for HLW
Japan	Reprocessing	Underground laboratory at Mizunami in granite since 1996
		• Used fuel and HLW storage facility at Rokkasho since 1995
		• Used fuel storage under construction at Mutsu, start up 2013
		NUMO set up 2000, site selection for deep geological repository under way to 2025, operation from 2035, retrievable

Geological disposal

Geological disposal, consisting of deep underground waste repositories, is often regarded as the safest and most secure solution to this lasting challenge. 25 of the 43 countries who will ultimately have to deal with this challenge have determined geological disposal as the answer and have some form of geological disposal plan in place, albeit at different stages of progress. Deep disposal routes are currently being actively implemented in Canada, France, Finland and Sweden.

According to Nuclear Energy Insider in 2013 the global market for nuclear decommissioning, waste treatment and disposal valued at over £250billion and the issue of ultimate disposal is a clear priority for the international nuclear industry. This is not likely to change, with new nuclear power spend set to reach £600billion over the next 20 years the amount of radioactive waste can only increase.

The principle of geological disposal is to isolate the waste deep inside a suitable rock formation to ensure that no significant or harmful quantities of radioactivity ever reach the surface environment. Geological disposal is a multi-barrier approach, based on placing packaged wastes in engineered tunnels at a depth of between 200m and 1000m underground, to protect them from disruption by man-made or natural events (e.g. flooding, coastal erosion, earthquakes or terrorist action) which primarily affect the surface.

Waste management for used fuel and HLW from nuclear power reactors - WNA Sept 2014

Country	Policy	Facilities and progress towards final repositories
Russia	Reprocessing	Underground laboratory in granite or gneiss in Krasnoyarsk region from 2015, may evolve into repository
		Sites for final repository under investigation on Kola peninsula
		Pool storage for used VVER-1000 fuel at Zheleznogorsk since 1985
		Dry storage for used RBMK and other fuel at Zheleznogorsk from 2012
		Various interim storage facilities in operation
South Korea	Direct disposal, wants to change	Waste program confirmed 1998, KRWM seet up 2009
		Central interim storage planned from 2016
Spain	Direct disposal	ENRESA established 1984, its plan accepted 1999
		Central interim storage at Villar de Canas from 2016 (volunteered location)
		Research on deep geological disposal, decision after 2010
Sweden	Direct disposal	Central used fuel storage facility – CLAB – in operation since 1985
		Underground research laboratory at Aspo for HLW repository
		Osthammar site selected for repository (volunteered location)
Switzerland	Reprocessing	Central interim storage for HLW and used fuel at ZZL Wurenlingen since 2001
		Smaller used fuel storage at Beznau
		Underground research laboratory for high-level waste repository at Grimsel since 1983
		Deep repository by 2020, containers to be retrievable
United Kingdom	Reprocessing	Low-level waste repository in operation since 1959
		HLW from reprocessing is vitrified and stored at Sellafield
		Repository location to be on basis of community agreement
		New NDA subsidiary to progress geological disposal
USA	Direct disposal but reconsidering	DoE responsible for used fuel from 1998, accumulated $32 billion waste fund
		Considerable research and development on repository in welded tuffs at Yucca Mountain, Nevada
		The 2002 Congress decision that geological repository be at Yucca Mountain was countered politically in 2009
		Central interim storage for used fuel now likely

X- Proliferation and Risks for Safety - NPT

The development of nuclear weapons is a historical watershed. It transformed international politics and gave an existential dimension to relations between the world's great powers.

Large stockpiles of weapons-grade plutonium were built up by both the Soviet Union and the United States during the Cold War. The U.S. reactors at Hanford and the Savannah River Site in South Carolina produced 103 tons, and an estimated 170 tons of military-grade plutonium was produced in USSR.

Each year about 20 tons of the element is still produced as a by-product of the nuclear power industry. As much as 1000 tons of plutonium may be in storage with more than 200 tons of that either inside or extracted from nuclear weapons. SIPRI estimated the world plutonium stockpile as about 500 tons, divided equally between weapon and civilian stocks. Since the end of the Cold War these stockpiles have become a focus of nuclear proliferation concerns.

Nuclear Forces 2010 –14					
Country*	2010	2011	2012	2013	2014
USA	9600	8500	8000	7700	7300
Russia	12 000	11 000	10 000	8500	8000
UK	225	225	225	225	225
France	300	300	300	300	300
China	240	240	240	250	250
Índia	60–80	80–100	80–100	90–110	90–110
Pakistan	70–90	90–110	90–110	100–120	100–120
Israel	80	80	80	80	80
Total	22.600	20.530	19.000	17.270	16.300
Source: *SIPRI Yearbook 2014*					
* Based on public information about plutonium production activities in North Korea. It is estimated that North Korea has produced 6-8 nuclear weapons.					

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 16,000. 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.

Nuclear Forces - 2014				
Country	**Operational weapons***	**Others Weapons**	**Total - 2014**	**Year of 1st nuclear Test**
USA	**2100**	**5200**	**7300**	**1945**
Russia	**1600**	**6400**	**8000**	**1949**
UK	**160**	**65**	**225**	**1952**
France	**290**	**10**	**300**	**1960**
China		**250**	**250**	**1964**
India		**90–110**	**90–110**	**1974**
Pakistan		**100–120**	**100–120**	**1998**
Israel		**80**	**80**	**. .**
North Korea			**6–8**	**2006**
Total	**4.150**	**12.200**	**16.350**	
Fonte: *SIPRI Yearbook 2014*				
* 'Operational Weapons are the weapons deployed on missiles or allocated on bases with operational forces.				
All data are estimates (January 2014).				

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.

Over the next thirty years, the United States plans to spend approximately $1 trillion maintaining the current arsenal, buying replacement systems, and upgrading existing nuclear bombs and warheads.

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:

Today, the maintenance and protection of the American nuclear arsenal is a trillion-dollar concern, while an incredible degree of both U.S. and global diplomacy is dedicated to preventing new countries from going nuclear. The mere fact that the human race is capable of wiping itself out within minutes is a recent development in world history.

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.

Treaty for the Prohibition of Nuclear weapons - NWFZs (nuclear weapons Free zone) have already been established in Latin America and the Caribbean (Treaty of Tlatelolco), the South Pacific(Treaty of Rarotonga), Southeast Asia (Bangkok Treaty), Africa (Pelindaba Treaty) and Central Asia (Treaty a Nuclear-Weapon-Free Zone in Central Asia) . These established NWFZs are of particular relevance to the examination of the material obligations to be included in the verification regime to be implemented in a future Middle East NWFZ.

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.

A positive point to be considered is the program ***Megatons to Megawatts (M2M)*** which, up to December 2013, eliminated the equivalent of a 20,000 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 more than 20 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.

Inside these cylinders lies uranium that was once part of a Soviet nuclear weapon.

Therefore the generation of energy from nuclear power in program ***M2M***contributed more than any other policy for the reduction of nuclear weapons on the planet. The program ended in 2013. It will have a pressure over the international uranium supply.

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.

Over 100 commercial power reactors, 46 experimental or prototype reactors, more than 100 mines, 250 research reactors and a number of fuel cycle facilities have been retired from operation. Some of these have been fully dismantled.

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.

Reactors closed prematurely by political decision or consideration (27)					
Country	**Reactors**	**Type**	**MWe net each**	**Years operating each**	**Shut down**
Armenia	Metsamor 1	VVER-440/V270	376	13	1989
Bulgaria	Kozloduy 1-2	VVER-440/V230	408	27, 28	dez/02
	Kozloduy 3-4	VVER-440/V230	408	24, 26	dez/06
France	Super Phenix	FNR	1200	12	1999
Germany	Greifswald 1-4	VVER-440/V230	408	10, 12, 15, 16	1990
	Muelheim-Kaerlich	PWR	1219	2	1988
	Rheinsberg	VVER-70/V210	62	24	1990
Italy	Caorso	BWR	860	12	1986
	Latina	GCR	153	24	1987
	Trino	PWR	260	25	1987
Japan	Fukushima Daiichi 5	BWR	760	33	2011
	Fukushima Daiichi 6	BWR	1067	32	2011
Lithuania	Ignalina 1	RBMK LWGR	1185	21	2005
	Ignalina 2	RBMK LWGR	1185	22	2009
Slovakia	Bohunice 1	VVER-440/V230	408	28	dez/06
	Bohunice 2	VVER-440/V230	408	28	dez/08
Sweden	Barseback 1	BWR	600	24	nov/99
	Barseback 2	BWR	600	28	mai/05
Ukraine	Chernobyl 1	RBMK LWGR	740	19	dez/97
	Chernobyl 2	RBMK LWGR	925	12	1991
	Chernobyl 3	RBMK LWGR	925	19	dez/00
USA	Shoreham	BWR	820	3	1989

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.

According to the WNA - World Nuclear Association, the following reactors have been or will be decommissioned due to accidents that somehow impaired them:

Reatores fechados após donos sofridos em algum acidente (11)						
Country	Reator	Tipo	MWe liq.	anos em operação	Fechamento	Motivo do fechamento
Alemanha	Greifswald 5	VVER-440/V213	408	0,5	nov/89	Derretimento Parcial do núcleo
	Gundremmingen A	BWR	237	10	jan/77	Erro de operação no desligamento
Japão	Fukushima Daiichi 1	BWR	439	40	mar/11	Derretimento do núcleo por perda de refrigeração
	Fukushima Daiichi 2	BWR	760	37	mar/11	Derretimento do núcleo por perda de refrigeração
	Fukushima Daiichi 3	BWR	760	35	mar/11	Derretimento do núcleo por perda de refrigeração
	Fukushima Daiichi 4	BWR	760	32	mar/11	Damage from hydrogen explosion
Eslovaquia	Bohunice A1	Prot GCHWR	93	4	1977	Core damage from fuelling error
Espanha	Vandellos 1	GCR	480	18	mid 1990	Incendio na Turbina
Suiça	St Lucens	Exp GCHWR	8	3	1966	Derretimento do núcleo
Ucrania	Chernobyl 4	RBMK LWGR	925	2	abr/86	Incendio e Derretimento do núcleo
EUA	Three Mile Island 2	PWR	880	1	mar/79	Derretimento Parcial do núcleo

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

Three 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 programs 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.

In addition to commercial nuclear power plants, there are about 240 research reactors operating, in 56 countries, with more under construction. These have many uses including research and the production of medical and industrial isotopes, as well as for training.

The use of reactors for marine propulsion is mostly confined to the major navies where it has played an important role for five decades, providing power for submarines and large surface vessels. About 150 ships are propelled by some 180 nuclear reactors and over 13,000 reactor-years of experience has been gained with marine reactors. Russia and the USA have decommissioned many of their nuclear submarines from the Cold War era.
Russia also operates a fleet of six large nuclear-powered icebreakers and a 62,000 tons cargo ship which are more civil than military. It is also completing a floating nuclear power plant with two 40 MWe reactors for use in remote regions.

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 new nuclear subsector, decommissioning and waste management, is also on the edge of an impressive "growth" agenda through a number of drivers: the dismantling, treatment, transport, and storage of material from a growing fleet of retired plants; a more progressive drive to minimize low, medium, and high level waste in the first place (in line with the waste hierarchy); and an increasing demand for improvement to state-of-the art operations and risk management, leading even to the "decommissioning" of old decommissioning sites.

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.

XIII – Major Sources of Information

- IAEA 2014, Country Nuclear Power Profiles
- Nuclear Technology Review 2014 (NTR 2014)
  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/*

- 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 2014
- *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
- INVAP -**http://www.invap.net/nuclear/carem/desc_tec.html**
- http://ec.europa.eu/energy/nuclear/safety/doc/swd_2012_0287_en.pdf
- http://www.world-nuclear.org/info/Nuclear-Fuel-Cycle/Nuclear-Wastes/Decommissioning-Nuclear-Facilities/
- **http://www.csmonitor.com/Environment/Energy-Voices/2014/0328/Thorium-a-safer-nuclear-power**