

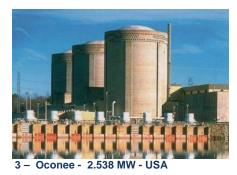
Worldwide Panorama of Nuclear Energy March 2012 Edition



1- Peach Bottom Atomic Power Station – 2.280 MW - USA



2 - Kozloduy 5 e 6 - 1.906 MW- Bulgaria



4 - Embalse - 600 MW - Argentina



5 -Vogtle 3 - AP1000 (Under construction) USA

Т







Summary



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Introduction

The waves that swept over Fukushima nuclear power plants moved on, albeit in a figured sense, and reached the major nations of the world.

Although most governments have taken a well thought-out position vis-à-vis the accident, and sought to review the safety of their facilities and learn from the acquired experience, in a few highly visible cases it has been seen that highly drastic measures have been adopted, often moved by different reasons associated with the politics internal to the respective countries, such as Germany, Italy, Belgium and Switzerland.

In our previous editorial, we warned that one of the consequences of the Fukushima accident might be, in some scenarios, "the World more polluted and saddled with more expensive energy".

In fact, Germany's decision to immediately close its older nuclear power plants has already led to a 12% increase in the country's electricity cost, and its carbon emissions have risen more than 10%.

Add to this the costs of capital investment in power plants, construction of substitute generation sources, and transmission lines for their integration. Not to mention the thousands of directly affected jobs. All of that at a time of acute economic restriction in the Euro zone.

The energy issue is crucial for modern society, and the building of a balanced energy mix that simultaneously meets the principles of universal access to electricity, safety of supply, and tariff moderateness calls for compromise solutions, diversification, heavy investments, and long maturity period.

Technology provides society with a number of solutions, each involving different associated costs, impacts, and risks. To this, geopolitics adds the challenge of ensuring a supply whose sources are totally or in part located beyond national borders, sometimes in unstable or even potentially hostile regions. It falls to national leaders to reflect in a serene, objective manner on the appropriate combination of alternatives to be followed, always bearing in mind that there is no energy generation approach or any other human activity that entails no environmental impacts or is risk free.

Opinion polls show a fall in the level of support for nuclear energy after the Fukushima Daiichi accident, not only in Japan, but all over the world. People oppose nuclear energy for a number of reasons, but a vague, indefinite fear predominates vis-à-vis little known technology risks. Political lobbies driven by antinuclear ideology or other covert objectives use the disinformation environment to impose their specific agendas which not always coincides with society's long-term interests.

Given this background, this paper seeks to provide the public with the latest data available on nuclear energy around the world, one of the safest and least environmental impacting source of energy.

This edition also features a new section on nuclear wastes in general, and particularly on radiation, where we seek to address in an accessible manner such concepts as equivalent doses, criteria, radiation measurement units, and radiation effects on living beings.



Worldwide Panorama of Nuclear Energy

I – Highlights of the November 2011 Edition

- 435 nuclear power reactors in operation with total installed capacity of 368,192 GW(and) (15/11/2011)
- 65 nuclear reactors under construction

| 435 nuclear powe | er reactors in | operation |
|--------------------|----------------|---------------|
| | | December 2011 |
| Country | Units | Total MW(e) |
| ARGENTINA | 2 | 935 |
| ARMENIA | 1 | 375 |
| BELGIUM | 7 | 5.927 |
| BRAZIL | 2 | 1.884 |
| BULGARIA | 2 | 1.906 |
| CANADA | 18 | 12.569 |
| CHINA +TAIWAN | 22 | 16.670 |
| CZECH REPUBLIC | 6 | 3.678 |
| FINLAND | 4 | 2.716 |
| FRANCE | 58 | 63.130 |
| GERMANY | 9 | 12.068 |
| HUNGARY | 4 | 1.889 |
| INDIA | 20 | 4.391 |
| IRAN, ISLAMIC | 1 | 915 |
| JAPAN | 50 | 44.102 |
| KOREA, REPUBLIC OF | 21 | 18.698 |
| MEXICO | 2 | 1.300 |
| NETHERLANDS | 1 | 482 |
| PAKISTAN | 3 | 725 |
| ROMANIA | 2 | 1.300 |
| RUSSIAN | 33 | 23.643 |
| SLOVAK REPUBLIC | 4 | 1.816 |
| SLOVENIA | 1 | 688 |
| SOUTH AFRICA | 2 | 1.800 |
| SPAIN | 8 | 7.514 |
| SWEDEN | 10 | 9.298 |
| SWITZERLAND | 5 | 3.263 |
| UKRAINE | 15 | 13.107 |
| UNITED KINGD OM | 18 | 10.137 |
| UNITED STATES OF | 104 | 101.240 |
| Total: | 435 | 368.192 |



In 2011, up to December:

- 435 nuclear power reactors in operation with an installed total net capacity of 368,192 GW(and)
- 5 nuclear power reactors shut down for a long period of time
- 63 nuclear power reactors under construction

New connections to the grid:

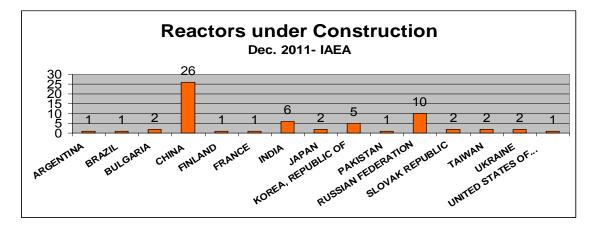
- Kaiga 4 (202 MW(and), PHWR, India) on 01/19/2011
- Chasnupp 2 (300 MW(and), PWR, Pakistan) on 03/14/2011
- Lingao 4 (1000 MW(and), PWR, China) on 05/03/2011
- CEFR (20 MW(and), FBR, China) Experimental fast breeder reactor on 07/21/2011
- Bushehr 1 (915 MW(and), PWR-VVER, Iran) on 09/03/2011
- Kalinin4 (950 MW(and), PWR-VVER, Russia) on 11/14/2011
- Qinshan 2-4 (610 MW(e), PWR, China) on 11/25/2011

Construction start date:

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

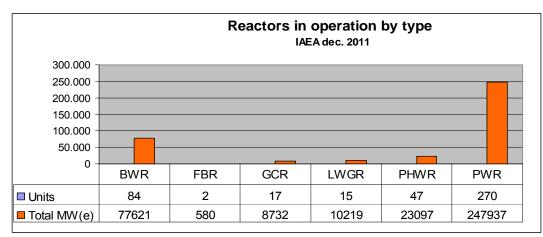
Definitive closure:

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



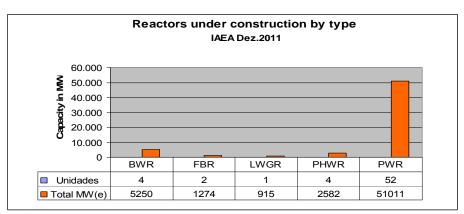
65 Countries holding no nuclear technology have expressed to the IAEA their interest in this matter, as they plan to build reactors and/or to develop an industrial nuclear capability.





435 Reactors in operation by type IAEA – December 2011

15 Countries, representing half of world population build 63 new reactors with total net capacity of 61,032MW.



63 Reactors under construction

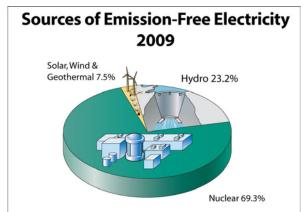
| Countries' region with interest in Nuclear | Quant. |
|---|--------|
| Asia / Pacific | 21 |
| Africa | 21 |
| Europe | 12 |
| Latin America | 11 |



II - Nuclear electricity generation Worldwide

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.



Source: Nuclear Engineering Institute

Total electricity generation data has been furnished by the companies involved, always on an annual basis. In 2010, the United States was the country that most generated electricity from nuclear power, accounting for around 32% of the world's total production of such form of energy.

Other leading electricity producing countries were: France (16%), Japan (11%), Germany (5%), Russia (6%), South Korea (5%), Canada (3%), Ukraine (3%) and China + Taiwan (4%). Brazil was responsible for 1% of the world's electricity generation from nuclear power. Countries showing smaller generation figures together (others) represented 2%.

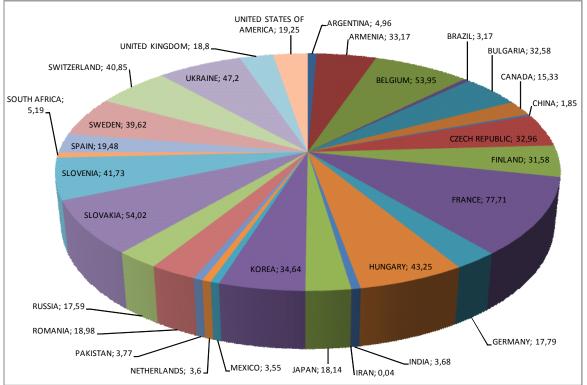
France totalled 407,900 GWh, but its mean capacity factor was 78.05; whereas in Japan production was 279,229.5 GWh with a capacity factor of 63.66%. France's fall in production was due to longer than planned outages. Japan had an increase in production with the recovery of part of its largest 8,212 MW capacity power station - Kashiwasaki-Kariwa, that was shut down after the 2007 earthquake.

The data on U.S. nuclear power plants are estimates, inasmuch as not all plants have released their reports in due time.

Germany produced 133,012 net GWh. In 2010, out of the world's ten largest nuclear generating plants, 6 are German - Isar 2, Brokdorf, Phillipsburg 2 Emsland, Grohnde, Unterweser; altogether, these produced 69,971.5 GWh.

The most recent projections by the IAEA – International Atomic Energy Agency on the nuclear energy's future in any scenario are higher than those for previous years (about 8% higher), with a forecast of 510 GW total installed capacity by 2030 in the case of smaller growth, and up to 810 GW for a high growth; that is, more than twice the current installed capacity.





Participation by country in the world nuclear power generation – 2011

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.

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

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



III - Distribution of Reactors

Among the largest electricity generating fleets, the following countries stand out: the United States with 104 units, France with 59 reactors and Japan, 53. In 2010, construction was started on fourteen new plants, and five new ones were connected to their grids. But mention should be made of the definitive closure of the Phenix (130 MW(and), FBR, France) on 02/01/10.

According to the World Nuclear Association - WNA up to November 2011 the experience gained all over the world by nuclear power reactors (summation of all reactors' years of operation), was more than 14,660 years, with the power generation of around 61,200 TWh.

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

| Suppliers | Reactors Type |
|-----------------|---------------|
| GE | ABWR/ESBWR |
| Westinghouse | AP1000 |
| Areva | EPR |
| AECL | ACR700 |
| Mitsubish | USAPWR |
| loshiba | ABWR |
| General-Atomics | GTMHR |
| Eskom | PBMR |

Limited Supply

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.

Post Fukushima

It is in Japan itself that supply problems are most critical. Japan Steel Works (JSW), which manufactures a number of components for nuclear power plants for such customers as Areva and

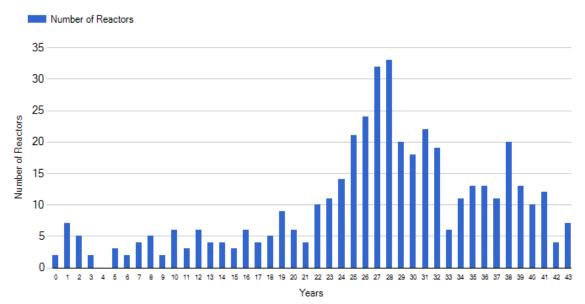


Toshiba, is seeking to attract additional customers for its production capacity so as to compensate for the severe impact on their business from the Fukushima disaster.

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

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

Up to October 2011, according to the IAEA, 80.6% of the operating reactors (346) around the world had been active for more than 20 years. Of these, 209 units had between 20 and 30 years, and 137 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.



Total Number of Reactors: 436

Source: IAEA March 2012



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

A - Americas



Nuclear Power plant position in North America

<u>Canada</u>

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|---------|-----------------------|----------------------------|-----------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| Canada | 18 | 13.553 | 0 | 0 | 90,034 | 15,33 |

Canada's total installed capacity up to 2010 was 129,974 MW, comprising a mix of hydro, thermal and nuclear sources, in addition to others such as wind, biomass, biogas and solar. Canada has 18 operating nuclear power plants (16 of them in Ontario) which generated 90.034 TWh or 15.33% of the country's electricity in 2011. All reactors are the PHWR type (pressurized heavy water reactor). The internal policy is primarily focused on a civil nuclear program for peaceful purposes and on reducing the greenhouse effect.

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.

The current policy concentrates on the refurbishment of existing reactors. Contracts for the refurbishment of Bruce A nuclear power station's plants 1 and 2 (PHWR 900MW each) for subsequent reconnection to the grid were signed in March 2009. These plants had been shut down since 1995. The Point Lepreau plant is also being refurbished.

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



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

Specialists have vowed that, without the participation of the Canadian government, it would be difficult for the CANDU technology to survive; but in June 2011 the SNC-Lavalin Group signed a purchase agreement for taking up the government's share in the AECL reactors division.



NRU at Chalk River – Canada (photo AECL)

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.

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.



Post-Fukushima

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.

Following the March 2011 disaster, nuclear fuel manufacturing company CAMECO CORP brought down its demand forecast for this year, inasmuch as 17% of its sales are destined for Japan. Notwithstanding, in a longer term, Canada does not expect a major fall in sales. The exports that were already contracted by Japan will be redirected to other countries.

In August 2011 an independent study of the Canadian government concluded that the construction of up to 4 new reactors on the site of the Darlington power stations would have no adverse environmental impact on the region. The government's decision on the nuclear power station is awaited.

<u>Mexico</u>

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|---------|-----------------------|----------------------------|-----------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| Mexico | 2 | 1640 | 0 | 0 | 9,313 | 3.55 |

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 2011 was 9,.313 TWh or 3.55% of the country's electric power. The power station's owner and operator is the state-run entity Comision Federal de Electricidad (CFE) which holds around 2/3 of the Mexican power grid's installed capacity, including transmission and part of the distribution network.



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

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

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



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

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

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

Post-Fukushima

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

United States

| Country | Reactors in operation | installed capacity (MW) | | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|---------------|-----------------------|----------------------------|---|----------------------------------|--------------------------------|-------------------------------------|
| United States | 104 | 107.714 | 1 | 1.180 | 790,225 | 19,25 |

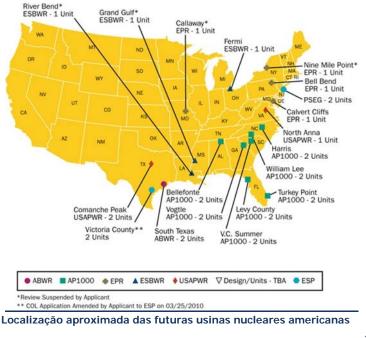
The United States are the owner of the world's largest nuclear fleet, with 104 plants in operation (69 PWRs and 35 BWRs), which correspond to an installed capacity of 107,714 MW; and in 2011 they produced 790,225 TWh(e). This figure corresponded to more than 31% of the world's entire nuclear energy and around 20% of that country's energy. Such amount is also approximately 70% of the electricity generated without greenhouse gas emissions.

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 6021 MW in March 2011, 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 139 applications have already been reviewed. As the NRC



reported in June 2011, an additional 11 requests (1372 MW) are pending review and other 34 may add 1840 MW to the grid by 2015.

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.



⁽http://www.nrc.gov/reactors/new-reactors/col/new-reactor-map.html)

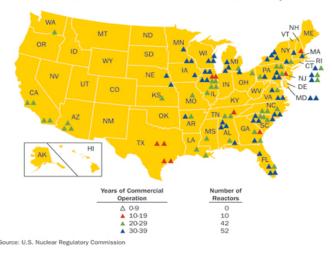
Another relevant fact to be underlined is the increase in the plants' useful lifetime, which is being extended to 60 years. In this case, 71 units now have their useful lifetime extended, which is equal to 68,245 MW functioning for more twenty years, with no capital costs involved in construction. In addition, the NRC – Nuclear Regulatory Commission is reviewing lifetime extension applications for 15 plants, and for an additional 18 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.

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), and the delivery of the nuclear fuel from Westinghouse has already been authorized by the NRC, with its loading into the reactor being scheduled for 2012. The status of construction in June 2011 was 62.5% completed.

On August 18, 2011 the TVA's Board of Directors approved the resumption of construction for Unit 1 (1260 MW - PWR) of the Bellenuclear source Power Station in the state of Alabama. The construction had been halted in 1988 due to the fall in electricity demand and to the attendant costs. The current cost estimate is 4.9 billion dollars. The PWR plant is a Babcock & Wilcox design, and the engineering and construction services have been awarded to AREVA.



U.S. Commercial Nuclear Power Reactors—Years of Operation



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

The plant, whose construction work is around 50% complete, is expected to be ready between 2018 and 2020, it being noted that the remaining construction phase is to be started when the fuel for Watts Bar-2 (construction under way) is loaded, in order not to undertake the construction of 2 nuclear plants at the same time.

Three hundred AREVA employees are working on that project, all of them based on the United States.



Bellefonte nuclear plant (The Tennessee Valley Authority's never-completed it, Alabama photo : Eric Schultz/Associated Press

The construction start date of the first AP1000 models in the United States is marked with the Vogtle-3 and -4 units in the state of Georgia, the first new American plants in 30 years. Southern Company has released video reports on land clearing and start of concrete work on the nuclear areas. Experience exchange with the Chinese is under way, who are building plants of such model in Sanmem and Haiyang. In addition, personnel preparation is being actively provided, with training programs focused on operation, maintenance, engineering, chemistry and health

Also in this 'new build' context, mention is made of the Summer nuclear power station's two new units (operator: SCE&G), in South Carolina, whose regulatory licensing process is under review



by the NRC, scheduled to be completed by January 2012. Work activities on land clearing, construction of crane bases, and other preconstruction activities are under way for the two AP1000 plants to be set on the site. The first unit is expected to come on line in 2016; and the second one by 2019.



Central de Vogtle http://www.southerncompany.com/nuclearenergy/photos.aspx

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.



Arkansas Nuclear One Generating Station Courtesy: Entergy Nuclear

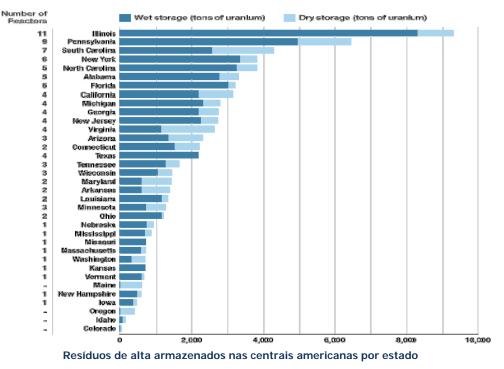
Plans also include using mixed uranium and plutonium oxide fuel withdrawn from dismantled nuclear warheads (there exist around 7 tons of plutonium available for such purpose), and tests are under way at the Browns Ferry plant owned by TVA, which has been subsidized by the U.S. Department of Energy (DoE) 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's new Secretary of Energy - Steven Chu – 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. Since the 1978 accident at the Three Mile Island station in Pennsylvania (with reactor loss of coolant and core partial melt-down, but no victims or radioactive release to the environment), no new-build reactor project has ever gotten started in that country. 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. Nuclear wastes

After the completion of the Yucca Mountain project, the decision on how and when the country will settle the nuclear wastes issue is still pending; notwithstanding, the NRC has already indicated that nuclear wastes can be safely stored for at least 60 additional years after the end of the plant's useful lifetime.



Post-Fukushima

The accident 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 competitive gas price.

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

In addition, at a conference on 09/20/2011, the secretariat of the U.S. Department of Energy (DoE) said the role of nuclear power is expected to greatly expand in that country, when climate changes are taken into account.



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 2011 (TWH) | % of total energy generated in 2011 |
|-----------|-----------------------|----------------------------|-----------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| Argentina | 2 | 935 | 1 | 692 | 5,892 | 4,96 |

Argentina has 2 operating nuclear power plants (Atucha 1- PHWR, 335 MW and Embalse PHWR, 600 MW), whose electricity production in 2011, was 5.89 TWh or 4.96% of the country's electricity grid. On the same Atucha 1 site, nearly 100 km away from Buenos Aires, Atucha 2 - PHWR, 692 MW is under construction. Embalse PHWR is supplied by Canada (CANDU design) and Atucha-1 and -2 are supplied by Germany (KWU/Siemens and successors). Construction work on Atucha-2 began in 1981, were suspended in 1987 and resumed in 2006. Completion was reached in September 2011 and the plant is in the pre-operational testing phase, expected to be completed in the second quarter of 2012.



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



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

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 cogeneration mode.

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

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

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

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

Post-Fukushima

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



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

<u>Brazil</u>

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.

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | 5 | % of total energy generated in 2011 |
|---------|-----------------------|----------------------------|-----------------------------|-------------------------------------|--------|-------------------------------------|
| Brasil | 2 | 1990 | 1 | 1405 | 15,664 | 3,17 |

Brazil has two nuclear power plants in operation (Angra-1, PWR, 640 MW and Angra-2, PWR, 1350 MW) whose electricity production in 2011 was 15.664 TWh or 3,17% 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 reais (around US\$175 millions).

On September 28, 2011, it was 11 years since the Angra-2 plant reached 100% of its rated power. The plant's electricity production in that period reached 105,419,518 MWh. Such amount of electric power would be enough the supply the city of Rio de Janeiro for eight years; Are Paulo, for five; and Brasília, for two decades.



Angra 3 – status of construction (Nov 2011) Reactor Building (photo Eletronuclear)

The country's electricity production is primarily supplied by hydropower; such generation accounted for more than 90% of the total in 2010. A strong economic growth is expected until 2030, and accordingly, a large increase in electricity consumption. Besides the construction of power plants with other fuel sources, plans to diversify Brazil's electricity mix (as per data from the energy research entity *Empresa de Pesquisa Energética - EPE*) contemplate the construction of 4 to 8 nuclear power plants within a time horizon up to 2030, located in Northeast and Southeast



Brazil. Site definitions, reactor types and other matters are under study at Eletrobras Eletronuclear and EPE.

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

Brazil also has four research reactors, two in Are Paulo, one in Minas Gerais and one in Rio de Janeiro. 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 tumours.

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, beside the Aramar Experimental Center, will be a solution to this problem, according to CNEN.

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

In the area of specialized personnel training, the University of Are 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 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.

Post-Fukushima

The Brazilian government took a cautious position with respect to accident, avoiding rash judgments, and ordered relevant technical reviews to assess the risks which the domestic nuclear plants could be subject to in the event of a severe accident. As with all countries, Brazil is studying the events and keeping track of the possible recommendations ensuing from the stress tests under way on all the world's nuclear power plants, mainly in Europe, besides conducting its own assessments and studies.

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.

<u>Venezuela</u>

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.

According to Venezuela's Communication and Information Minister, a single large nuclear reactor can replace 15 million oil barrels in electricity generation, which may represent one billion dollars in foreign exchange revenues from oil exports.

Post-Fukushima

After Fukushima, the country's president has apparently changed his mind and is now giving more weight to the risks than the benefits of nuclear energy.

<u>Chile</u>

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.

Post-Fukushima

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.

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



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 (2011- Global Nuclear Power Outlook).

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



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

1) pre-assessment by the nuclear power plant operator itself answering a EU questionnaire;

2) the answers are checked by the country's regulatory body;3) a review is done by an international committee of experts.

The questions have to do with: ability to resist such natural disasters as earthquakes, tsunamis,



floods or other extreme natural conditions; ability to withstand man-made events, whether by terrorism or neglect (blasts, airplane crashes, fire); and what preventive measures are taken to avoid and/or mitigate such events.

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.

Europe has no significant sources of uranium and 80% the European plants' feed material come from Russia, Kazakhstan, Canada, Australia and Niger.

<u>Armenia</u>

| Cou | untry | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|-----|-------|-----------------------|----------------------------|-----------------------------------|-------------------------------------|--------------------------------|---|
| Arm | enia | 1 | 375 | 0 | 0 | 2,357 | 33,17 |

Armenia is an ex-soviet republic with around 3.2 million inhabitants. The country has 1 plant in operation - Armenia 2 (PWR, 375MW) and another permanently closed 1989.

In 2011 its sole plant in operation produced 2.357 TWh of electricity, which accounted for 33.17% 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.

Post Fukushima

The country will conduct the same safety tests as the EU nations, although not being a member of the Bloc.

<u>Austria</u>

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



Nuclear Power Station Zwentendorf, Áustria (Closed)

Austria has a ready plant that never operated due to a referendum decision (majority of the population 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.

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.

<u>Belgium</u>

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|---------|-----------------------|----------------------------|-----------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| Belgium | 7 | 6092 | 0 | 0 | 45,942 | 53,95 |

Belgium has two nuclear power stations, Doel with 4 plants (PWR, 2963 MW) and Tihange with 3 units (PWR, 3129 MW). The plants have been operating for 25 to 35 years and are licensed for 40 years.

45.942 TWh were produced by nuclear source in 2011, which accounted for 53.95 % of the country's electricity generation. The older plants - Doel-1 (412-MW), Doel-2(454-MW) and Tihange-1 (1,009-MW) extended the useful life for more 10 years, that is, up to 2025.

At present, the policy to phase out all reactors up to 2025 is being severely questioned. Costs will be huge, bringing losses to security of supply, dependence on international sources, and increased emissions. This diminished the country's competitiveness, as indicated in the report - Belgium's Energy Challenges Towards 2030, which strongly recommends returning to nuclear electricity generation.

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

In the research area, the government approved a resolution in March 2010 authorizing use of resources of the future research reactor Myrrha (Multi-Purpose Hybrid Research Reactor for High-Tech Applications) for development of innovative solutions in energy and nuclear medicine.

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



permanent storage facilities for high-level radioactive wastes.

Post-Fukushima

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.

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.

<u>Bulgaria</u>

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|----------|-----------------------|----------------------------|-----------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| Bulgaria | 2 | 1.906 | 2 | 2.000 | 16,314 | 32,58 |

Bulgaria has 2 nuclear power plants (KOZLODUY 5 and 6 – VVER-PWR 953 MW, each) in commercial operation, which accounted for 15.24 TWh, approximately 32.58%, of electricity generation in 2011. Two plants are under construction (Belene 1 and 2 VVER PWR 1000 MW) and 4 are 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.



NPP KOZLODUY

Bulgaria's NEK - National Electric Company holds 51% in the nuclear power plant project at Belene (2x 1000 MW - VVER) and signed a contract with Russia's Atomstrovexport for design, construction and commissioning of the plant's units, but the price is above what the country accepts to pay, which may bring about construction contract performance delays. The results of safety stress tests performed all over Europe are under review and the relevant recommendations will be implemented where appropriate. The concrete foundations for the reactor have been placed. An equipped geotechnical laboratory for soil studies, a water treatment station and a concrete batching plant have been built. The contract will be valid until 2012.

Consortium 'CARSIB' (Consortium Areva NP-Siemens for Belene) has been engaged as subcontractor to provide electrical and instrumentation and control (I&C) systems. In addition, commercial agreements have been signed with Finnish Fortum and French Altran Technologies, whereby they are given a percentage of the plant-generated electricity in payment for their work. A contract awarded by Bulgaria is in progress (in the amount of 2.6 million euros) for site selection and design of a near-surface disposal facility for low- and intermediate-level radioactive wastes.



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.

Post-Fukushima

The Belene Project is on hold, awaiting the safety analyses under way and, depending on the results, the possibility exists that the new reactor designed for that site - which is more exposed to seismic activity - will be transferred to the Kozloduy site. Bulgaria maintains its strategic plans to expand nuclear energy generation by means of a new nuclear plant and by extending the lifetime of the existing Kozloduy plants to lower its dependence on Russia for primary energy (gas and oil).

Czech Republic

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|------------|-----------------------|----------------------------|-----------------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| Rep. Checa | 6 | 3760 | 0 | 0 | 33,27 | 32,4 |

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 25 TWh in 2010, accounting for 32.4% of the country's electric power.



Dukovany – Czech Republic (Image: Petr Adamek)

There are plans (with environmental impact studies in progress) to add two other reactors to the Temelin site, which was originally designed for 4 reactors, but for political reasons only 2 were built.

An international competitive bidding process on the supply of the two new reactors has been initiated, with suppliers from France (AREVA), U.S./Japan (Westinghouse) and Russia (Rosatom) trying to sell their products. Offers will be received until July 2012 and the winner is to be announced in 2013.

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). 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.

Post Fukushima

The Czech government declared that will proceed with its plans for construction of new nuclear plants.

On request of the Czech government, the country's oldest nuclear power plant (Dukovany) went through a safety inspection by the IAEA (Operational Safety Review Team - OSART) in June 2011, 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.

England and Northern Ireland (UK)

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|---------|-----------------------|----------------------------|-----------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| England | 17 | 11,442 | 0 | 0 | 69,00 | 18,8 |

The United Kingdom has 17 plants in operation (11,442 MW installed capacity) and 26 closed for having reached the end of useful lifetime or obsolescence. It is Europe's oldest fleet, with closed

| Sítios revisados como possíveis para instalação de nova usina | Empresa(s) interessada(s) |
|--|------------------------------|
| Hartlepod | EDF Energy |
| Heysham | EDF Energy |
| Sellafield | NDA |
| Oldbury | NDA e EON |
| Wylfa Peninsula | NDAeRWE |
| Hinkley Point | EDF Energy |
| Bradwell | NDA |
| Sizewell | EDF Energy |

Fonte: Platts 18.10.2010

plants that started operation in the 1950's and 1960's. In 2011, the country produced 69.00 TWh of energy from nuclear source (18.8% of the total).

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

Accordingly, the country is expected to realize the domestic goals of cutting by 34% the greenhouse gas emissions until 2020, when 40% of electricity consumption in the United Kingdom



are estimated to come from low-carbon sources, with renewable and nuclear energy, as well as carbon capture and sequestration technologies.

Building a new fleet of nuclear power plants is part of the carbon emission reduction policy existing in the country and such plants are planned to start operation by 2017, replacing the oldest nuclear facilities (the one that last started to operate dates back to 1989) and those already closed. Company Horizon Nuclear Power - joint venture formed by E. ON UK and RWE AG, which will be filing license applications for the Wylfa Peninsula and Oldbury sites is already working and expected to have the documentation ready up to 2012.

For the Hinkley Point site, where 2 old plants already exist, EDF has submitted the initial documentation for an EPR 1600 (Hinkley Point C), in the region of West Somerset and has placed orders with AREVA for such plants' heavy components.

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.

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.

Post-Fukushima

5/07/2011 - According to Britain's Minister of Energy and Climate Change, Charles Hendry, "The U.K. government remains absolutely committed to new nuclear power plants; without them, the nation would be darker and less prosperous".



Hinkley Point C (ilustration- WNA)

"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.

Nuclear wastes

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

Finland

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|---------|-----------------------|----------------------------|-----------------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| Finland | 4 | 2.780 | 1 | 1.720 | 22,278 | 31,58 |

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



As it decided, in 2002, for the construction of a fifth nuclear unit, Finland dispelled the situation that prevailed in West Europe, where it was a long time since proposals for new nuclear construction were presented. The importance of the Finnish decision lies on the fact that it was preceded by detailed analyses with public participation and extensive political discussions.

Nuclear Power Plant Olkiluoto 3 (photo AREVA)

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.

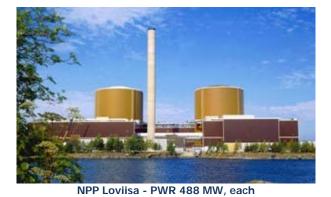
Olkiluoto 3 plant (1,600 MW, EPR) is now scheduled to start operation in 2014. It will be the first plant with the EPR reactor design created by French AREVA.

The Project is showing a delay of nearly 5 years vis-à-vis the original plan, with the start of operation now being scheduled for September 2013.



Several problems (construction, licensing, subcontracting, etc.), arising from the fact that such plant is the first of a kind of new reactors, and that qualified, experienced labor does not exist in sufficient quantity in either Finland or the countries involved in the project would be at the root of the delays occurring so far. Areva's estimated losses up to end of this Project come to 2.7 billion euros. Nevertheless, in July 2010, the Finnish parliament approved the country's 6th reactor (more than 1 reactor per one million inhabitants).

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



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

(photo Fortum) 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 wastes

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

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

Post-Fukushima

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

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



Fortum (51% held by government) has a 26% stake in Teollisuuden Voima Oyj (TVO) and is planning to participate in the financing and engineering of Olkiluoto's plant 4.

France

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2010 (TWH) | % of total energy generated in 2010 |
|---------|-----------------------|-------------------------------|-----------------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| France | 59 | 65.880 | 1 | 1.720 | 421,100 | 77,71 |

The country's total installed capacity is 123,001 MW and electricity production was 550.3 TWH. France has 59 operating nuclear power plants (on 19 different sites). Eleven plants on shutdown (useful lifetime over) produced 421.1 TWh, which represents 77.71% of the country's total generated electricity in 2011. EDF is the utility that operates the entire fleet. Among these, the Phenix plant is a research reactor.

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

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. Another EPR 1700 is planned to be built on the Penly plant site, in the north of France. Among the plants existing in France, 34 are of the 900MW-PWR class, the operation of which was declared satisfactory by the regulator (ASN) for up to 40 years' lifetime (French plants have an estimated operational period of 30 years), but each is required to go through a safety review to validate such lifetime license. Tricastin-1 (915-MW, PWR) was the first reactor subjected to review and authorized for more 10 years.

According to the RTE – the French grid operator, on account of the country's ageing generating fleet, as early as 2013 France is possibly expected to have supply problems during peak-load times if the plants' useful lifetime has not been extended. 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 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, the construction being scheduled to start in 2012. 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).

In October 2010, EdF opened up a bidding process on the supply of 3 large sized turbine sets, one for the Penly plant, and two for the future Hinkley Point C plants in England.





Flammanvile - 3 (photo Areva)

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.

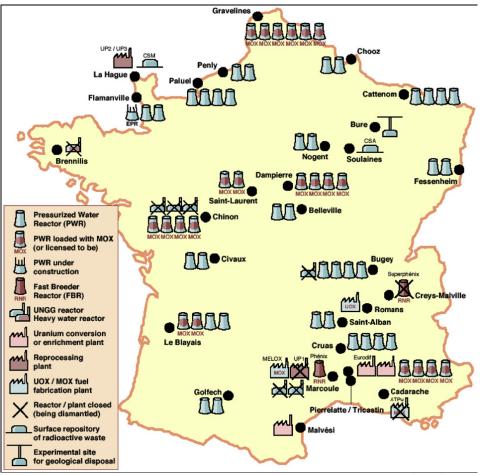
Among other sites, Auxon and Pars-lès-Chavanges in the State of Aube are currently conducting studies for a low-level waste repository possibly expected to start activity in 2019 (replacing those that have reached saturation). Such sites are part of the **40** applicant communities wishing to host the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

The work on ITER - International Thermonuclear Experimental Reactor under construction in the region of Cadarache, southeast France, had its costs inflated, up from 5 billion to 15 billion pounds, 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.

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





Location Map of France 's nuclear installations Source: Marignac e tal. (2008)

Post-Fukushima

After the accident, a ten years' lifetime extension was authorized for the FESSENHEIM-1 plant which has been operational since 1978. This is the oldest French reactor in operation.

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

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

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



Marcoule Accident

The Marcoule low-level radioactive waste treatment facility had an accident on 09/12/2011. The event was a chemical explosion followed by fire, with no release of radioactive material.

<u>Germany</u>

| Country | | | Reactors under construction | capacity under construction (MW) | 0 | % of total energy generated in 2011 | |
|---------|----|--------|-----------------------------|-------------------------------------|---------|-------------------------------------|--|
| Germany | 17 | 21.366 | 0 | 0 | 102,311 | 17,79 | |

Germany has a total installed capacity of 161,570 WW, with a nuclear generating capacity of 21,366 MW from 17 operable plants, but only 9 actually are generating power, because eight (Kruemmel, Brunsbuettel, Biblis A and B, Isar 1, Neckarwestheim 1 and Phillipsburg 1) have been shut down for political and legal reasons in Germany. Out of the remaining nine plants, six are among the 10 largest nuclear electricity generators in 2010. Nuclear plants produced 102.311 TWh in 2011, accounting for 17.79% 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.

Domestic *per capita* consumption is 6,300 kWh/year (around 3 times that of Brazil).

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.

Post-Fukushima

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.

After the Fukushima accident, once again Germany's government changed mind to overturn the 2010 position that favored operating life extension, as shown in the table below:

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.



| Plant | Туре | MWe (net) | Commercial | Operator | Provisionally scheduled | 2010 agreed | March 2011shutdown |
|---------------------|------|------------|------------|------------|-------------------------|-------------|-----------------------|
| rian | | | operation | Operator | shut-down 2001 | shut-down | & 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 |
| lsar-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 |] | | | | |

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.

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 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.

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 country is investing in Bulgaria's Belene (2x 1000 MW – VVER) nuclear power station project through German electricity generation company RWE, which holds a 49% stake of the total 1 billion euros investment (the other part belonging to company Electrabel - GDF Suez). This project began in 1987, was subsequently suspended, and resumed in 2007. The construction agreements are signed.

Hungary

| Country | Reactors in operation | capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|---------|-----------------------|---------------|-----------------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| Hungria | 4 | 2000 | 0 | 0 | 14,711 | 43,25 |

Hungary's 4 nuclear power plants (Paks 1 to 4 – VVER-PWR 500 MW) whose commercial operation started between 1982 and 1987 have produced 14.711 TWh, that is, around 43,25% of the country's electricity generation in 2011. 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.

Post-Fukushima

June 2011 – State-owned company MVM has plans to expand the capacity of its Paks nuclear plants and accordingly increase its influence on the energy markets of its vicinity (Balcans-Croatia, Serbia and Bosnia and in Rumania). The decision to expand Paks nuclear power station is to be published in September, with the preparatory work being under way as authorized by the Parliament.

Test results on the Hungarian plant have been satisfactory according to the governmental regulatory body, requiring no additional safety measures.





NPP Paks – Hungary

Pal Kovacs – Hungary's Minister of National Development declared that for all energy planning scenarios studied by the country, nuclear supply is indispensable. The 2030-2050 energy plan recommends a 20 years' lifetime extension for the 4 units of Paks nuclear station, whose useful lives would be over in the period from 2032 to 2037. In addition, the country intends to expand by 2,000 MW the station's capacity (2 new 1000 MW units, each) until 2025. The cost is estimated at 10 billion dollars.

<u>Italy</u>

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

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

Italy has no nuclear power plants in operation. The phase-out of its 4 plants - Caorso; Enrico Fermi (Trino Vercellese); Garigliano and Latina – was completed in July 1990 (2 by popular decision and 2 for completion of useful lifetime). Italy is the only country in the G8 – group of the world's richest countries plus Russia – that does not operate nuclear power plants. Notwithstanding, around 10% of the electricity consumed in its territory are from nuclear power, imported mainly from France, where 74% are generated by nuclear plants.

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.

Post Fukushima

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 2011 (TWH) | % of total energy generated in 2011 |
|------------|-----------------------|----------------------------|-----------------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| Netherland | ds 1 | 482 | 0 | 0 | 3,917 | 3,6 |

NPP Borssele – Netherlands (Image: EPZ)

The Netherlands has only one nuclear plant in operation (Borssele PWR 482 MW). In 2011, it produced 3.917 TWh, or approximately 3.6 % 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 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



2018, in time to realize the greenhouse gas reduction goal of at least 15% by 2020. 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 process will be a long one and the agreement is the starting point. In June 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.

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.

The country imports more than 20% of its electricity (mostly from Germany). The energy per capita consumption is 6,500 kWh/ year.

Post-Fukushima

The Netherlands' only nuclear plant will go through the EU stress test. In June 2011, the use of MOX fuel was authorized.

According to the government, the Netherlands will continue its nuclear program contemplating the construction of the new nuclear power plant.

<u>Norway</u>

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.

<u>Romania</u>

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|---------|-----------------------|----------------------------|-----------------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| Romania | 2 | 1414 | 2 | 1440 | 10,70 | 19,5 |

Romania has 2 nuclear power plants (Cernavoda 1 and 2- PHWR 650 MW) in commercial operation with 19.5% of electricity generation from nuclear reactors in 2010. The two plants are



operated by SNN - Societatea Nationala Nuclearelectrica. Units 3 and 4 (720 MWe Candu, each) are going through financing problems, being scheduled to start commercial operation by 2016.

An agreement between six investor companies - ENEL (9.15%), CEZ (9.15%), GDF Suez (9.15%), RWE Power (9.15%), Iberdrola (6.2%), and ArcelorMittal Galati (6.2%) - and Romania's SNN- Societatea Nationala Nuclearelectrica (51%) was signed on November 20, 2008 for completion of the reactors at Cernavoda-3 and -4 (PHWR Candu -750 MW each), on the same site of the operating plants 1 and 2.



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

In 2011, companies European Iberdrola (6.2%), RWE Power (9.15%), GDF Suez (9.15%), CEZ (9.15%), gave up participating in the project due to the market and economic uncertainties, and SNN- Societatea Nationala Nuclearelectrica started to hold 84.65% of the investment. The country produces its own fuel since the 1980's at the Pitesti Nuclear Fuel Plant (FCN).

Due to financing difficulties, Romania's government had not provided the promised funds, and SNN was unable to cover the project's costs.

Post Fukushima

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.

<u>Russia</u>

| Country | | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|---------|----|----------------------------|--------------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| Russia | 33 | 24.242 | 10 | 8.830 | 155,11 | 17,09 |

Russia has 33 plants (25,242 MW) in operation (15 of them equipped with the RBMK reactor or LWGR – the same model used in Ukraine's Chernobyl plant), 10 plants under construction (1RBMK, 1 FBR and 8 VVER) and 5 planned plants.



In July 2008, the director general of Rosatom - Russia's state-run nuclear company, Mr. Sergei Kiriyenko, said that the Russian government has plans for the construction of 42 new nuclear plants up to 2020, which will corresponds to around 42 GW. In 2010, Russia produced 155,11 TWh of electricity from nuclear source. accounting for approximately 17.09% of its electric grid, it being expected that 25% or 30% will be reached by 2020. The country's per capita consumption is nearly 3 times greater than Brazil's, for a population of around 142 million inhabitants.



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

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.

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

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

The focus on nuclear electricity generation by Russia's energy policy is aimed at enhancing natural gas exports to Europe – a more profitable business than its use for domestic electricity generation – and the replacement of generating fleet, which is nearing the end of its useful life



Control Room of Reactor Leningrad(RBMK or LGWR)

Russia has been signing a series of commercial and cooperation agreements with several countries for construction of new reactors, nuclear fuel development and exploitation and research in the nuclear area in general, setting up an extensive network of influence around the world. According to Russian government leaders, this should allow the country to be a trading partner in 30% of new business transactions in the nuclear area, and to possibly hold 38% of the nuclear reactors and services market by 2030.



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

Rosatom, Russian state-run nuclear company is planning to build the Baltic nuclear power plant (two reactors) 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, recently closed). In November 2011, Russia's regulatory body – Rosetekhnadzor awarded the license for the nuclear plant.



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

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 In view of the findings of power shortage studies on the Baltic region foreseeing a capacity deficit of 2,000 MW, Russia has guaranteed to private investors the large potential of that plant, whose units are planned to operate in 2016 and 2018 respectively. The project also includes the transmission line that will distribute electric power to neighbors (BRELL – Belarus, Russia, Estonia, Latvia and Lithuania).

the municipal library to inform the region's residents on the environmental impact of the plant.



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



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.

Post 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.

Since the Fukushima event, Russia has kept the construction of Leningrad power plant 2 (second phase), signed construction contracts for a new plant in Belarus and reaffirmed its plans to build the first nuclear power plant in Turkey, both already meeting the requirements arising from Fukushima.

Iran's reactor built by Russia is in final preparation to come into commercial operation and a new business agreement with Bangladesh should be signed by the end of the year.

<u>Slovakia</u>

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|------------|-----------------------|----------------------------|-----------------------------|-------------------------------------|-----------------------------------|-------------------------------------|
| Eslováquia | 4 | 1.896 | 2 | 880 | 14,342 | 54,02 |

Slovakia's 4 nuclear reactors in commercial operation produced 14.342 TWh of electricity, in 2011, which accounted for 54.02% of the country's energy generation. The two units under construction are Mochovce-3 and -4 (VVER 440MW each) and are expected to come into operation in 2012 and 2013 respectively. Plans also contemplate the construction of 2 other reactors in the period from 2020 to 2025.

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





NPP Mochovce (www.seas.sk/en/news)

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.

Post-Fukushima

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.

<u>Slovenia</u>

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|----------|-----------------------|----------------------------|-----------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| Slovenia | 1 | 656 | 0 | 0 | 5,902 | 41,73 |

Slovenia has 1 nuclear reactor - KRSKO (PWR, 656 MW) in commercial operation since 1983. In 2010, KRSKO produced 5.902 TWh of electricity, supplying 41.73 % of the country's electric grid. The reactor is shared (50%) with Croatia.

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.

Post-Fukushima

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.



<u>Spain</u>

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|---------|-----------------------|----------------------------|-----------------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| Spain | 8 | 7.728 | 0 | 0 | 55,064 | 19,48 |

Spain has 8 nuclear reactors (6 PWR and 2 BWR) in operation, with a total 7,728 MW installed capacity. In 2011, 55.064 GWh of electricity were produced, corresponding to 20.09 % of the country's total electricity generation.

Two other reactors have been shut down: Vandellos 1 in 1990 - on which the decommissioning work is in an advanced stage, and Zorita-Jose Cabrera in 2006, whose decommissioning has been awarded to Westinghouse.



NPP Vandellos 2 – Spain

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.



NPP Almaraz-Trillo

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



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.

Post-Fukushima

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.

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.

<u>Sweden</u>

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|---------|-----------------------|----------------------------|-----------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| Sweden | 10 | 9.281 | 0 | 0 | 58,022 | 39,62 |

Sweden has 10 nuclear reactors in operation that produced 58.022 TWh of electricity in 2011. 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, for political reasons.

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.







NPP Oskarshamn- 3 units (2.308 MW) – Sweden

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.

Nuclear wastes



Östhammar – Sweden Selected site for construction of waste storage

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

spent fuel.

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

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.



Post Fukushima

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.

Another consequence is the financial loss world-class sustained by energy conglomerates, such as Swedish stateowned Vattenfall (37,500 direct jobs worldwide), ensuing from the shut-down of its generating units in Germany (Brunsbuettel and Kruemmel) with a 18% drop in the net sales vis-à-vis the preceding year.



Visitors at test lab Aspo Hard Roch photo: Ingrid Becker/KQED

Switzerland

| Country | | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|-------------|---|----------------------------|-----------------------------|----------------------------------|--------------------------------|-------------------------------------|
| Switzerland | 5 | 3.352 | 0 | 0 | 25,20 | 38,01 |

Switzerland has 5 operating nuclear reactors (3,352 MW installed capacity distributed in PWR and BWR type reactors) which produced 25.20 TWh of electricity in 2010, accounting for around 38% of the country's electric grid. With a population of 7.6 million, this represents approximately one reactor per each million and a half inhabitants.

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

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

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

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



Producers of medical wastes pay a fee to the government which is responsible for all such services.

Post Fukushima

Although not a member of the Bloc, Switzerland will do the same tests as other nations of the EU. The conclusions from the preliminary tests are that the nuclear plants have high safety levels.

Three construction applications for new nuclear plants were under review by Swiss federal authorities when the accident occurred and, as a consequence the processes were put on hold.

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

<u>Ukraine</u>

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|---------|-----------------------|----------------------------|-----------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| Ukraine | 15 | 13.880 | 2 | 2.000 | 83,80 | 48,11 |

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 2010, Ukrainian nuclear power plants produced 83.8 TWh, representing 48.10% of the country's electric power. Ukraine's primary energy sources are coal, gas and uranium, but gas – as well as oil – is imported from Russia, which also supplies nuclear fuel. Such energy dependence has brought political problems for the country which would like to find substitutes for energy supplies.

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

NPP Khmelnitski



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

According to data from the World Nuclear Association – WNA there exist 22 planned reactors in Ukraine, with 9 being intended to

replace older ones scheduled to be shut down by 2035, and thirteen are new plants to meet country's future consumption requirements.

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.

Post Fukushima

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

Other European Countries

Baltic countries (Lithuania, Estonia, Byelorussia and Latvia)

Being too small to bear the construction costs of a nuclear plant, the Baltic countries wish to join into a consortium to build a plant. Together, they can also benefit from lines of credit which they are entitled to with the Nordic Investment Bank. The Project may also include Poland.



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

March 2009. Byelorussia In signed an agreement with Russia. through its Atomstroyexport, for the construction of the country's first nuclear plant. An international competitive bidding process was launched for the supply of technology and construction services. In addition. on 10/11/2011 а construction contract was signed with Russian AtomStroyExport (ASE) for two plants in Bvelorussia. This will be a turn-key project at an estimated cost of around 9 billion dollars, with the first plant to be commissioned in 2017. The Ostrovetsk site in the region of Grodno has been



selected for the project (2 x VVER -1200 MWe AES-2006).

Post Fukushima

The Byelorussia Project will go through same tests as those applied to EU nations, although the country is not a member of the Bloc.

<u>Lithuania</u>

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.

Post Fukushima

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.

Poland

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

To reduce its CO2 emissions, Poland is now pondering the possibility of building its first nuclear power plant by 2020, a move to starting changing its electricity mix.

The Polish government commissioned its major power company (PGE - Polska Grupa Energetyczna SA) to conduct the country's first two nuclear power plant projects which are



planned to have a 3000MW capacity, with two or three reactors each. It is expected that the first plant will come on stream by 2020.



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.

Síte in Zarnowiec – Poland

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).

Post Fukushima

In July 2011, Poland's Parliament passed the last law necessary for the start of construction of the country's first Nuclear power station.

As soon as President Bronislaw Komorowski signs the law, gigantic state-owned Polska Grupa Energetyczna - PGE will be allowed to commence construction work on up to 2 plants, with a capacity for up to 6 GWe, which are expected to be ready by 2020. The selected technology should belong to one of the competitors - AREVA, GE Hitachi and Westinghouse - invited to submit bids until January 2012. Bidding results will be published in 2013, as informed by the PGE.

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



C - Africa / Middle East / Africans Countries

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.

South Africa

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

South Africa's two operating reactors (Koeberg 1 and 2 - PWR 900 MW each), produced 12, 923 TWH in 2011.

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.



Central Nuclear Koeberg (Photo by: Ruvan Boshoff)

Post Fukushima

Minister of Energy - Dipuo Peters reiterated the government's commitment to nuclear energy and renewable sources, aimed at electricity mix diversification and greenhouse gas reduction. According to him, 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.

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.



Arab Emirates

The United States has signed a cooperation agreements (pending approval by the U.S. Congress) with the Arab Emirates in furtherance of a civil nuclear energy program planned to put into operation, by 2020, three nuclear power plants with 1,500 MW capacity, each.

South Korea won the bidding for the construction of the Arab Emirates' first nuclear power station (4 APR-1400 reactors). The other competitors were AREVA (with the EPR reactor) and GE Hitachi (ABWR). The contract signed on December 27 by the Korea Electric Power Corporation (Kepco) and Emirates Nuclear Energy Corporation (ENEC) comes to 40 billion dollars and contemplates the construction of 4 nuclear units by 2020, intended to supply 25% of country's electricity.

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

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

Post Fukushima

In late March 2011 a ceremony was held to celebrate the construction starting date of the Emirates' Braka nuclear power plant, attended by representatives from the Emirates Nuclear Energy Corporation and Kepco. South Korea's president, Lee Myung-bak and Abu-Dhabi's Prince, Mohamed bin Zayed Al Nahyan were present at the ceremony. The Fukushima accident has not brought changes to the country's nuclear policy.

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, and talks with Russians are under way.

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 2020 onwards, followed by others up to 2030. The government expects nuclear energy to reach 20% of the domestic consumption over the next 20 years.



Egypt

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

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

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

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

<u>Israel</u>

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.

<u>Jordan</u>

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





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

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

Image of first reactor of Jordan (KAERI)

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.

In the mean time, Jordan has signed a uranium mining agreement with AREVA for a 25 years' duration and called bids from Areva (France), AECL (Canada) and Atomstroyexport (Russia) for a 1,000 MW nuclear power project. 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.

Results of an assessment commissioned to a specialized consulting firm to define the technology for its first 1000 MW nuclear plant are expected in the first quarter of 2012. AREVA, Mitsubishi, Atomstroyexport and Atomic Energy of Canada are the competitors for such project.

Post Fukushima

The Fukushima accident has brought no changes to the nuclear policy of Jordan, with 2 power reactors being contemplated over the next 10 years, on which technical offers were submitted in July 2011. The nuclear project is to be located in Majdal, 40 km north of Amman, and the nuclear plant design calls for the use of water from a nearby wastewater treatment facility for cooling purposes.

<u>Namibia</u>

Namibia has no nuclear electricity generation plants, but it is Africa's top producer of uranium and the world's fourth largest. According to governmental sources, the country will use such potential to develop its nuclear industry and to generate electricity through nuclear power plants intended to complete the country's energy mix. The policy on uranium and nuclear energy is focused on the entire fuel cycle and should be ready by mid 2011 as informed by the Minister of Mines Isak Katali, at the first event (November 2010) organized with the assistance of Finland's regulatory body for stakeholders of the area.



<u>Nigeria</u>

According to Nigeria's Atomic Energy Commission (NAEC), Nigeria is planning to build a nuclear power station over the next three years 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.

<u>Kenya</u>

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 4200 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.

<u>Turkey</u>

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, on a separate site yet to be licensed.

Successive bidding cancellation announcements and the subsequent reinstatement of agreements have made the process in Turkey very uncertain, but not closed. Talks are going on with Russia and South Korea.

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).

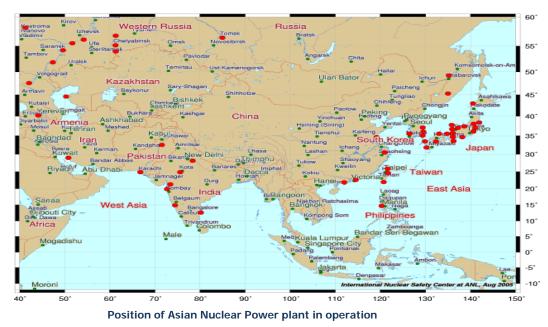
Post Fukushima

The country will do the same tests as EU nations, even though it is not a member of the Bloc. The Fukushima accident has brought no changes to the country's nuclear policy.

18/08/2011 – Turkey is holding talks with Japan on the second nuclear power station with four reactors to be built at Sinop, on the Black Sea coast. The construction consortium would be led by Japanese party and the operation would be assigned to a third country.



D - Asia



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.

<u>China</u>

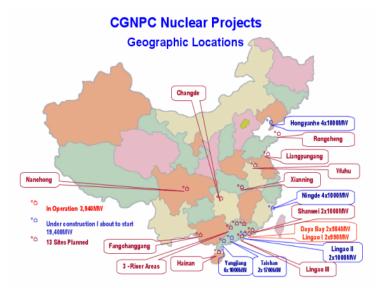
| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|---------|-----------------------|----------------------------|-----------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| China | 16 | 11.816 | 26 | 29.317 | 87,40 | 1,85 |

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

As far as nuclear energy is concerned, the country has, up to March 2012, 16 nuclear power plants in operation (11,816 MW) and the Chinese government contemplates the construction of 54 new plants over the next 30 years. According to the IAEA, 26 plants are now under



construction (with a total capacity of 29,317 MW) and 16 new reactors have been approved for start of construction. All large vendors have already submitted offers to the Chinese government, inasmuch as this is, today, the world's biggest nuclear power business. To AREVA alone China will pay 12 billion dollars for 2 already contracted EPRs.



Location of Nuclear Power plant in China

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, 55 GW by 2020 and 70 GW by 2025. Given such capacity, China should come to 5% of electricity generation from nuclear power by 2030.

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 September 2011 (manufactured in bv Korea's Doosan Heavy Industries & Construction). The design estimates a 60 years' useful life for such plant, whose commercial operation is expected for 2013. When completed. Sanmen will host 6 AP1000 reactors, with the second unit scheduled to come into operation by 2014.





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 selfsufficiency 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.

Haiyang 2 (AP-1000) – maio 2011 (photo CNECC)

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

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

Nuclear wastes

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

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

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

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.





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

Post Fukushima

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 80 nuclear GW planned for 2020, according to Xu Yuming, Secretary General of China's Nuclear Energy Association (May 2011).

India

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|---------|-----------------------|----------------------------|-----------------------------------|----------------------------------|-----------------------------------|-------------------------------------|
| India | 20 | 4.391 | 7 | 4.824 | 28,948 | 3,68 |

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

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

Infrastructure, generation, transmission and distribution requirements are expected to necessitate governmental spending of 150 billion dollars, according to a consultant KPMG.



India develops its own program of nuclear electricity generation with emphasis on PHWR reactors (18 units), mostly with 220 MW capacity. It also has 2 BWR reactors (150 MW each).

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

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

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.



Two reactors (950 MW -VVER) under construction at Kudankulam, India. (Photo: Atomstroyexport)

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.

Post Fukushima

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 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. Plans for emergency defense and preparedness are ready, and the NPCIL – Nuclear Power Corporation of India Ltd, operator of Indian reactors [which has already gone through extreme cases in its plants - for example: power failure at the Narora plant in 1993; flood in Kakrapara, 1994; and impact from the tsunami on Madras, Indian Ocean, 2004] started to implement them. Such experiences are of much help in the efforts now planned for nuclear facilities.

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.

<u>Iran</u>

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (MWH) | % of total energy generated in 2011 |
|---------|-----------------------|----------------------------|-----------------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| Iran | 1 | 1.000 | 0 | 0 | 0,04 | 0 |

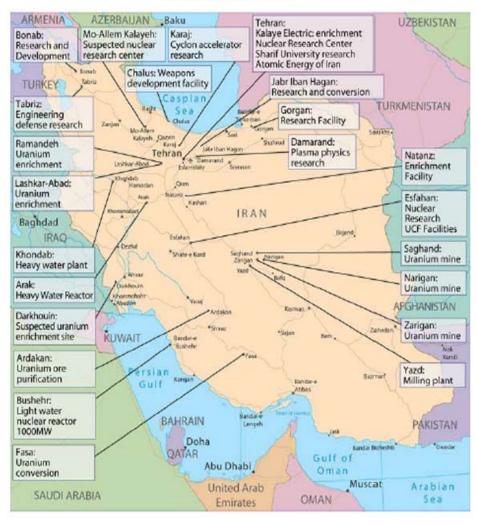


NPP Bushehr, Iran (photo : Atomenergoproekt)



Iran has a plant in operation (Bushehr, PWR 1000 MW) connected to the grid on September 4, 2011, after several delays caused by a number of reasons.

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. Plant operation, fuel supply and waste storage will be handled by Russia over the next 3 years.



Iran Nuclear Sites

Sites with nuclear activities in Iran

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.



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 tonnes of low enrichment uranium (LEU) for conversion abroad (probably in Russia) and transformation into fuel for a research reactor in Teheran.

Post Fukushima

The government has not announced its position on safety measures to be taken in connection with the Fukushima event, even because the government has yet to handle the usual problems associated with its sole plant's start of operation.

<u>Japan</u>

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

Japan's 50 reactors (44,114 MW) in operation produced 156,182 TWh in 2011, accounting for 18,14 % of the country's electricity. There exist 2 plants under construction (Shimane 3 and Ohma 1 – ABWR 1300 MW, each) and nine reactors permanently shut down. There are also plans for power upgrade and useful life extension.

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

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 cooldown 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.



NPP Fukushima-Daiichi after the first wave tsunami

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.

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.

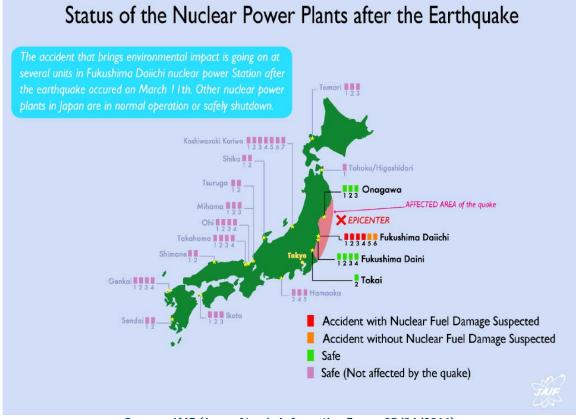
In addition to the losses of human lives, Japan will be facing economic losses from industry's inactivity caused by breakdowns, unavailability of infrastructures or power failures triggered by the disaster.

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.

In October 2011 were in operation 11 of the 54 reactors previous to the earthquake (Tomari-3; Kashiwazaki-Kariwa-5 and -6; Mihama -2, Ohi-2, Takahama-2 and -3; Shimane-2; Ikata-2; Genkai-1 and 4). Most of the ones shut down are going through stress tests similar to the EU model, plus the annual inspections legally called for in Japan. The government ordered all affected reactors to remain shut down up to completion of tests. Analysts believe the tests can be done with the reactors in operation and that the government uses safety as a politically-oriented move, given that the already feeble economic conditions following the earthquake and tsunami are expected to aggravate with the planned stark rationing programs during the coming winter. In November 2011, nuclear plants in operation were only 18.5% of the country's nuclear capacity and, in terms of energy generation, were 9.4% of the total grid, or 6.73 TWH. In March 2012 was in operation only one reactor (Tomari 3).



Source : JAIF (Japan Atomic Information Forum 05/04/2011)

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 Japanese government is planning to use rubble from the earthquake on wood-fuelled electricity generating plants, thus mitigating two problems: electric power shortage and rubble disposal.

By September 2011, access restrictions had been lifted for 5 areas evacuated in a radius ranging from 10 to 20 Km, the population being authorized to return to their homes. 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.

Nuclear Waste

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

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

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

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

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

In July 2010, Japanese companies Tokyo Electric Power, Chubu Electric Power, Kansai Electric Power, Toshiba, Mitsubishi Heavy Industries, and Hitachi informed that they were planning to set



up a new business organization (International Nuclear Energy Development of Japan) to export nuclear power projects to emerging countries, but the Fukushima accident is likely to change this prospect.

<u>Kazakhstan</u>

| | Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | 0 | % of total energy generated in 2011 |
|---|------------|-----------------------|----------------------------|-----------------------------|----------------------------------|---|-------------------------------------|
| 1 | Kazakhstan | 0 | 0 | 0 | 0 | 0 | 0 |

Kazakhstan has no electricity generating plants, but only one research reactor at the Institute of Nuclear Physics, near Almaty.

Due to its large uranium production capacity (world's largest producer of uranium ore) Kazakhstan holds a great weight in the nuclear industry. The country is capable of converting high enriched (HEU) into low enriched uranium (LEU) in its Ulba plant (Ulba Metallurgical Plant in Ust-Kamenogorsk), as it did in August 2011 when 33 kg of HEU were converted into LEU, as reported by the U.S. National Nuclear Security Administration - NNSA) which is cooperating with Kazakhstan to modify the research reactor and render it capable of using LEU fuel.

<u>Pakistan</u>

| Country | | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|----------|---|----------------------------|-----------------------------|----------------------------------|-----------------------------------|-------------------------------------|
| Pakistan | 3 | 725 | 1 | 315 | 3,83 | 3.77 |

Pakistan has three operating nuclear power plants (Chasnupp 1 and 2, PWR 300 MW each and Kanupp, PHWR - 125 MW) in the Punjabe region and another under construction (Chasnupp 3 – PWR, 315 MW). In 2011, 3.830 TWh of electricity from nuclear source were generated, about 3.77% of the country's total in the period. In November 2010 the country announced a contract was signed with China (China National Nuclear Corporation - CNNC) for construction of the fifth unit.



NPP Chasnupp - Pakistan (photo Rosatom)

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



weapons parity with other countries holding nuclear weapons in the region.

In April 2009, it was reported that the Pakistani government approved the construction of two additional nuclear reactors to be located in the Chashma Nuclear Power Complex, for a 340 MW installed capacity each, with China providing the technology and enriched fuel. Inasmuch as Pakistan is a holder of nuclear weapons, China did not disclose any details of the deal to avoid further controversy on this issue.

In June 2010 an agreement with China was announced that will allow the construction of two new reactors for 650 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.

Post Fukushima

In May 2011 construction of the country's fourth nuclear plant was started (Chashma Nuclear Power Plant Unit 3, also known as Chasnupp 3), with China being the responsible contractor. The reactor, expected to come into operation by 2015, is a 340 MW PWR.

South Korea

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|-------------|-----------------------|-------------------------------|-----------------------------------|-------------------------------------|--------------------------------|-------------------------------------|
| South Korea | 23 | 20.313 | 3 | 3,640 | 147,677 | 34.64 |

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 (20,313 MW installed capacity). In 2011, these nuclear power plants produced 147.677 TWh, accounting for around 34.64 % of the country's electricity consumption. Five plant projects are under way, with a 30 GW increment expected by 2015, it being noted that approximately 5,500 MW relate to ongoing construction and an additional 3,000 MW will ensue from signed contracts nearing start of construction. The latest plant to come into commercial operation was Shin-Kori 1 (PWR - 960 MW) in August 2010 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.

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





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.

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).

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 up to 2012.

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.



NPP Shin-Wolsong 1 and 2 - Image AIEA

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.

Post Fukushima

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 and Jordan. Despite the fall in Korean public satisfaction with nuclear energy due to the Fukushima accident, the forecasts on new reactors indicate 29 units against the previous projection 33. The country is planning to go on with its nuclear expansion, and even such old plants as Kori 1 (1978) keep generating electricity.

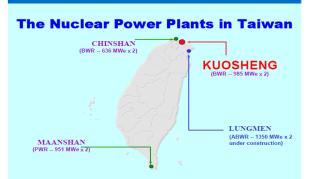


In July 2011, an international commission of nuclear experts from the IAEA visited Korea to assess good practices developed in Korea. Recommendations for improvements were made in the light of the Fukushima event, and no non-conformances were found that might compromise the safe operation of the plants.

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.

<u>Taiwan</u>

| Country | Reactors in operation | installed capacity (MW) | Reactors under construction | capacity under construction (MW) | generated energy 2011 (TWH) | % of total energy generated in 2011 |
|---------|-----------------------|----------------------------|-----------------------------|----------------------------------|--------------------------------|---|
| Taiwan | 6 | 4.980 | 2 | 2.600 | 40,522 | 19.02 |



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 2011 was 40.522 TWh, accounting for 19,02 % of the country's electricity. Chinshan plants 1 and 2 (BWR 636 MW each) started operation in 1978 and 1979 respectively. Kuosheng 1 and 2 (BWR 985 MW each). Maanshan plants are PWRs with 951 MW each.

Location of NPP in Taiwan

Post Fukushima

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

<u>Vietnam</u>

Vietnam's minister of industry and trade has announced plans for 2 nuclear power plants in the Ninh Thuan province, with two reactors each, expected to be operational between 2020 and 2022.

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



According to the Director of the Vietnam Agency for Nuclear Safety and Radiation, Plant 1 - with 1,900 MW capacity - will be based on Russian technology. In addition, memoranda have already been signed on training for the country's new specialists. The construction is scheduled to start by 2014.

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

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

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

Reactors Planned and Proposed up to 2027 - Vietnam

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.

Post Fukushima

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.

<u>Asia – Others</u>

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



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

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



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

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

Bangladesh signed an agreement with Russia on November 1, 2011 for the construction of two 1,000 MW nuclear power plants in the Rooppur region, northwest of Bangladesh, expected to be operational by 2018. 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.

Post Fukushima

In September 2011, the Ministry of Foreign Affairs of Bangladesh, Dipu Moni, informed that the country should have its first plant operable by 2022. 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.



V - Acordos Comerciais e de Cooperação Nuclear

Countries and governments associate according to their needs and strategies, always seeking higher profits and/or security for their energy supply. While not exhausting the subject, the following are some publicly known signed agreements.

United States and Others:

United States – China

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

United States – Arab Emirates

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

United States – Kuwait

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

United States – Persian Gulf Countries

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

United States – France

1 - AREVA and NORTHROP GRUMMAN have signed an agreement for setting up a company -Areva Newport News LLC – to fabricate heavy components (reactor vessels, cover, steam generator and pressurizer) for the French EPR reactor in the United States planned to start operation by 2011. AREVA expects to build up to 7 reactors in the U.S. over the next years and such strategy is meant to cope with a possible industrial bottleneck for heavy components, given



the reduced number of heavy components manufacturers around the world.

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

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

United States – Italy

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

United States – Czech Republic

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

United States – South Africa

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

United States – Vietnam

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

Rússia e Outros:

Russia – United States

Russia's nuclear fuel producer TENEX-Techsnabexport has announced the U.S. Department of Commerce's approval of the deal to supply enriched uranium for the Constellation Energy Nuclear Group, in the period 2015 - 2025. This is Tenex's sixth fuel supply agreement on the American



nuclear electricity generation market. The others were with Exelon and Fuelco (that represents Pacific Energy Fuels, Union Electric or AmerenUE) and Luminant.

Russia - Australia

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

Russia – United Kingdom

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

<u>Russia – Japan</u>

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.

<u>Russia – China</u>

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

Russia – Netherlands

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

<u>Russia – Bulgaria</u>

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



Russia – Nigeria

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

<u>Russia – India</u>

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

Russia – Italy

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

Russia – 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.

<u>Russia – Jordan</u>

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.

<u>Russia – Egypt</u>

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

Russia – Slovakia

Russian company TVEL has signed a long-term nuclear fuel supply contract with a company Slovenské Elektrárne, plant owner and operator, to supply fuel for Mochovce units 3 and 4



(VVER-440). Contract activities covering 5 reloads and associated services are planned to start by 2012, when the plants are scheduled to come into operation. Italian ENEL is the owner's majority partner.

Russia – Turkey

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

Russia – Ukraine

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

Kazakhstan and others

Kazakhstan has no nuclear power plant, but it is the world's largest uranium producer, ahead of Canada and Australia, since December 2009.

Kazatomprom - national nuclear corporation has 21 mines in operation in Kazakhstan and will be strategically involved in the construction of nuclear power plants in China as a means to diversify its business, currently dominated by mining.

The agreement signed with China Guangdong Nuclear Power Group (CGNPG) and China National Nuclear Corp (CNNC), will set up a company with Kazatomprom holding 51%, which will build plants in China and develop uranium mines on Kazakhstan's Irkol deposit in the Kyzylordinskaya region, whose annual production capacity is estimated at 750 tonnes of U3O8; on Semizbay deposits in Akmolinskaya (annual production capacity estimated at 500 tonnes of U3O8) and on Zhalpak deposits, annual production capacity estimated at 750 tones of U3O8. 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 tonnes 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 tonnes 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.

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.

<u>Jordan – Japan</u>

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.

<u>Jordan – Turkey</u>

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 - 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.

<u>Argentina – Canada</u>

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.



<u>Argentina – Saudi Arabia</u>

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.

<u>Argentina – South Korea</u>

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).

<u>Canada – India</u>

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.

<u>Canada – Vietnam</u>

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.

China and others

China – South Africa

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

<u>China – Belgium</u>

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).

<u> China – Taiwan</u>

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.

<u> China – Canada</u>

1- Agreement for development of advanced fuel design signed between Atomic Energy of Canada Ltd (AECL), Third Qinshan Nuclear Power Company (TQNPC), China North Nuclear Fuel Corporation and Nuclear Power Institute of China for use of the spent fuel from China's reactors on CANDU reactors in Canada and in China. The agreement also includes the use of thorium as a fuel.

2- CAMECO (Canadian uranium giant) has signed a supply agreement with Chinnuclear energy Industry Corporation (CNEIC) for around 10 tonnes of uranium concentrate up to 2020. The company is also negotiating a long-duration agreement with China Guangdong Nuclear Power (CGNP)

3- CAMECO signed a long-duration supply agreement with China Guangdong Nuclear Power Holding Co (CGNPC). The deal will ensure supply for the Chinese company whose nuclear fleet is growing at a steady pace.

China – France

1- Agreement between AREVA (45%) and China Guandong Nuclear Power Company – CGNPC (55%) for setting up a joint venture intended to compete anywhere in the world for nuclear construction projects by offering French (EPR) and Chinese (CPR1000) reactor models.

2- Another agreement has to do with UraMin, a company owned by AREVA to which Chinese investors would allocate capital, ensuring an interest of 49% in the company's equity, and subsequent Chinese access to UraMin produced uranium. In this process, UraMin will hold a captive market in China, where as France, guaranteed return on investments.

3- A third agreement, in November 2010, concerns a contract for 3.5 billion dollars covering a 10 years' supply of 20,000 metric tonnes of uranium for China Guandong Nuclear Power Company.

4- Under the fourth agreement, AREVA and China National Nuclear Corp.- CNNC set up a joint venture (CAST) for production and marketing of zirconium tubes for fabrication of fuel assemblies as early as 2012.

5- The fifth agreement deals with industrial cooperation in the field of spent-fuel treatment and recycling.

France and others

France – 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 – 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 – Congo

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

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 – 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 – 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 – 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.

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.

<u> France – Brazil</u>

1- France, through AREVA, has signed with Brazil a memorandum of understanding on industrial cooperation aimed at expanding Brazil's fleet of nuclear power plants and the fabrication of nuclear fuel for new plants to be built.

The focus will be on the nuclear program's major components, such as administrative, legal, and contractual framework; technical excellence; and financial and economic aspects, besides information exchange on the nuclear fuel cycle; procurement and supplier management; nuclear power plant construction, commissioning and operation.

2- French group GDF Suez and Brazilian companies Eletrobrás and Eletronuclear have signed an agreement for cooperation in the nuclear area. Such cooperation "protocol" will be basically focused on "exchange of information and experience" in the nuclear field. According to Suez, efforts will also be centered on such issues as nuclear power plant operation, technology, ownership arrangements, construction site selection process, and development of human resources.

Brazil – European Union

The Brazilian government closed an agreement with the European Atomic Energy Community (EURATOM) for research in the area of nuclear fusion which will include exchange of scientific and technical information, exchange of scientists and engineers, organization of seminars and conduct of studies and projects.

South Korea – Czech Republic

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



South Korea – Egypt

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

South Korea – Jordan

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.

<u>United Kingdom – Jordan</u>

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.

<u>Japan – Poland</u>

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.

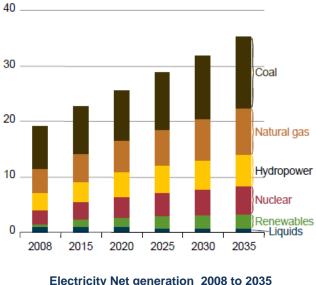


VI – Environment and Society

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

Energy is the key to the planet and to mankind's way of living. It assures jobs, safety, food production, transportation and everything else. In the lack of it, the world's economies, countries, ecosystems, etc., do not work.

Nuclear energy is technology is the most mature, lowest carbon-emitting technology available, being capable of generating large quantities of energy to supply the needs of society in quality, quantity and reliability.



Source: EIA-US DoE (in trillions of kWh)

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

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

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

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

The availability and accessibility of energy, especially electric power, have become indispensable



for modern society's working conditions. Energy supply security is a concern for all governments, as it facilitates essential services for production, communication and commerce.

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

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

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

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

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

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

The United States (DoE) have invested 17 million in fellowships for university researchers, for the specific purpose of developing-next generation power reactor technology, thus seeking to maintain a lead in this field. In addition, the Idaho National Laboratory (INL) is investing 50 million in the construction of a center dedicated to research and education in the nuclear area, which is part of the program to upgrade laboratory infrastructures.

The Fukushima accident is expected to somehow delay this entire worldwide process, but should not cancel it.

Another point to be considered is the program *Megatons to Megawatts* which, up to August 2011, eliminated the equivalent of a 17,000 nuclear warheads, through recycling of 500 million tonnes (MT) of highly enriched uranium (90%) which was converted into fuel for nuclear electricity generation plants. The program is expected to continue up to 2013.



VII – 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. 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.



Yellowcake production – Photo INB



Uraniumo - phto INB

In addition, the costs associated with the resource's classification are naturally contingent on the production method involved. Around 60% of the world's uranium production comes from mines in Canada (20.5%), da Australia (19.4%) and Kazakhstan (19.2%). 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 tonnes a year.

| Country | Production - 2009 (tU) | Production - 2010 (tU) | Resources (tU) <us\$80 kg<="" th=""></us\$80> |
|----------------------|------------------------|---------------------------|--|
| Kazakhstan | 14.020 | 17.803 | 344.200 |
| Canada | 10.173 | 9.783 | 329.200 |
| Australia | 7.982 | 5.900 | 714.000 |
| Namibia | 4.626 | 4.496 | 145.100 |
| Niger | 3.243 | 4.198 | 44.300 |
| Russia | 3.564 | 3.562 | 172.400 |
| Uzbekhstan | 2.429 | 2.400 | 55.200 |
| USA | 1.453 | 1.660 | 99.000 |
| Ukraine | 840 | 850 | 126.500 |
| China | 750 | 827 | 44.300 |
| Malawi | 104 | 670 | N.D. |
| South Africa | 563 | 583 | 205.900 |
| India | 290 | 400 | 0 |
| Czech Rep. | 258 | 254 | 600 |
| Brazil | 345 | 148 | 157.400 |
| Romania | 75 | 77 | 0 |
| Pakistan | 50 | 45 | 0 |
| France | 8 | 7 | 0 |
| Total | 50.773 | 53.663 | |
| Fonte: WNA, OECD/NEA | • | - | |

World production grew 6% in 2010, with Kazakhstan being again the biggest producer. In 2010 the greatest producing companies were Kazatomprom (Kazakhstan); Cameco (Canada), Areva (France), Rio Tinto (Australia) and Atomredmetzoloto (Russia). They all have business in all continents.

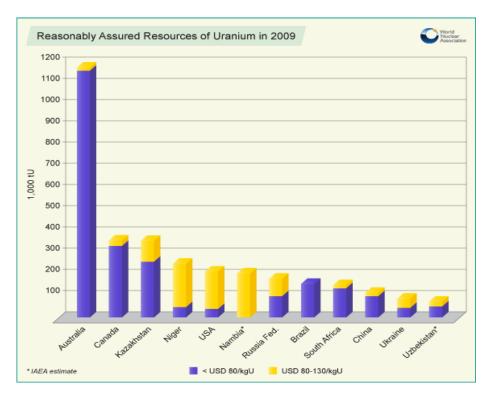
According to KazAtomProm (Kazakhstan's state-owned mining company) as the nuclear industry develops and uranium supply on the secondary market diminishes, the possibility arises of a nuclear fuel deficit on the market. Therefore, the company is getting prepared through a production increase and capacity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

In contrast, Canada and Australia have cut back their productions, whereas Russia and Uzbekistan have kept theirs at steady levels.

Uranium is mined in 20 countries, 7 of them (Australia, Canada, Kazakhstan, Namibia, Niger, Russia and Uzbekistan) accounting for 90% of the production.

At present around 68 thousand tonnes 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.



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 U3O8 is expected to grow from 44.4 thousand tonnes to 110 thousand tonnes 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 tonnes 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 tonnes 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.

Besides putting the new mine into operation, the company is planning to treble the production of the Caetité mine, in Bahia, which will reach 800 tonnes in 2012 and 1.2 thousand tonnes in 2014. Thus, INB's production will jump from the current 400 tonnes to 2.7 thousand tonnes in 2015, when Angra 3 plant will come on stream, representing a growth in uranium concentrate consumption of around 290 tonnes every 14 months.



TORIUM

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

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

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

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

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



VIII – Spent Fuel, Radiation, Waste and Reprocessing

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

Spent Fuel

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

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

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

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



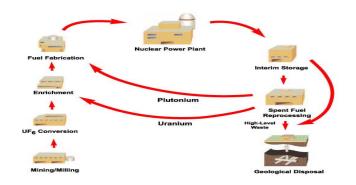
Under the second strategy, the used fuel is considered waste and preliminarily stored until its final disposal. The 50 years' experience with handling this material has proven safe and efficient in both technologies that have been used so far - Wet and Dry storage technologies. In both cases, the spent fuel is first stored in the reactor's pool and subsequently in interim repositories that can be located in the nuclear power plant itself.

Usina de Reprocessamento Sellafield Cumbria – Inglaterra

Today, the countries reprocessing nuclear fuel are China, France, India, Japan, Russia and the United Kingdom. Those that store for future reprocessing are Canada, Finland and Sweden.

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





Nuclear Fuel cycle

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

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

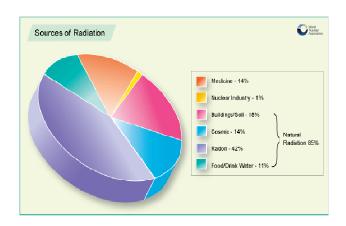
The development of innovative solutions such as the Myrrha project (Multi-Purpose Hybrid Research Reactor for High-Tech Applications) in Belgium offers other possibilities for nuclear waste treatment such as transmutation. Although a large capacity plant is still a long way off, a pilot project (at a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

Radiation

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

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.





Only 15% of emittions come from mankind activities (medicin and nuclear industry)

| Types of Radiation | Characteristics |
|--------------------|--|
| ALFA | Does not penetrate the skin - only dangerous if ingested |
| ВЕТА | can be blocked by wooden / aluminum, etc Little danger |
| GAMA RAY | dangerous for people - must be isolated |
| X RAY | dangerous for people - must be isolated |
| COSMIC RADIATION | Particles provenients from space |
| NEUTRONS | produced by nuclear fission, can cause harm to human beings - must be isolated |

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

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

| medical procedures | Dose in mSv |
|------------------------|-------------|
| dental radiography | 0,005 mSv |
| mammography | 2,000 m Sv |
| Brain Scan | 0,8 a 5 mSv |
| Breast Scan | 6 a 18 mSv |
| Gastrointestinal X-ray | 14,0 mSv |



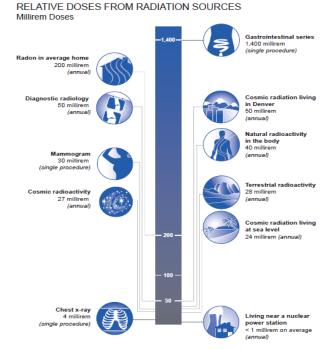
The SI unit for radiation exposure is the Sievert (Sv) and its multiples, the milli Sievert – mSv (1 mSv = 0.001 Sv) and the micro Sievert - $\mu Sv = 0.000001 Sv$).

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:

 μ Sv/h = 1 millionth of the Sievert per hour of exposure (0.000001 Sv/h)

Another unit used is the Rem, which is equal to 0.01 Sv.



From EPA – Radiations: Risks and Realities

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

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

<u>Radioactive contamination</u> is the presence of radioactive material in any place where it is not desired, therefore, a radioactive material without any contention control.

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 μ Sv/h, varies a lot, and is known in most cases. Below are a few examples of radiation dose per hour of exposure in μ Sv/h:



| Average dose of radiation measured | μSv/h |
|---|-------|
| individual Average due background radiation | 0,230 |
| individual Average due background radiation - Americans | 0,340 |
| individual Average due background radiation - Australians | 0,170 |
| Average at <u>Fukushima on</u> 25/05/2011 | 1,600 |
| Average at Tóquio City on 25/05/2011 | 0,062 |

Examples of radiation doses per year of continuous exposure:

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

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 penetrant gamma and neutron radiation. Still, if ingested, inhaled or introduced into the body through wounds, the radioactive material can be taken to the vicinity of critical organs and irradiate them in such internal position. The amount of radiation received from an external source can be controlled by simply keeping the source away.

Once the material has been inhaled and/or ingested, it continues to irradiate the body until it is eliminated naturally by the organism. Some radionuclides remain in the body for a long period of time – months or even years. The biological effects of the ingested radioactive material are identical to those produced by external radiation, since contamination emits radiation.

The internal location of the material emitting alpha radiation and beta radiation allows these radiations to affect the organs and tissues, which would not normally occur due to their low capacity of penetration.

Nuclear and Radioactive Wastes

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



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

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

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

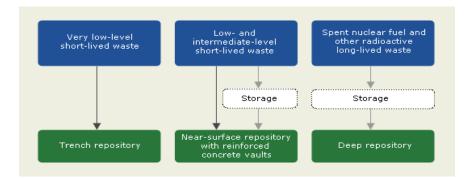
Repository for Low- and Intermediate- Level Wastes

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

Development of Containers for Spent Fuel Transportation and Storage

Purpose: To define, develop, build and qualify a transportation container and a storage container for spent-fuel from nuclear power plants.

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

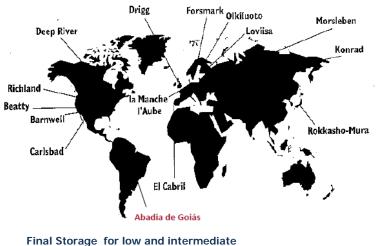


Low- and intermediate-level radioactive wastes from nuclear power plants consist in general of materials used in cleaning operations, replacement parts, clothing, shoe covers, and gloves used inside reactor buildings, impurities, filters, etc.

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

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





levels in World

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

Inasmuch as such wastes are of a much smaller magnitude than the wastes from fossil-fueled power plants, *e.g.* based on coal, and since nuclear power plants in general provide ample space for waste storage during the plant's useful lifetime, there is no urgency in implementing a final solution for waste conditioning. This makes it possible to carefully develop plans and policies for closing of the nuclear fuel cycle, including final waste disposal.

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

source: EIA_US DoE 2011

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



IX- Proliferation and Risks for Safety - NPT

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

The 189 signatories to the landmark 1970 arms control treaty – which is aimed at preventing the proliferation of nuclear weapons and urges those countries with atomic warheads to relinquish them – get together every five years to assess compliance with the terms of the pact and the progress made toward achieving its goals. The last review conference on the NPT was in May 2010 and the next will be held in April 2012 in Vienna. Western specialists say that if this conference is successful, it will lead to a declaration covering the three pillars of the NPT: disarmament, nonproliferation, and the peaceful use of nuclear energy.

| Country | Strat | egic | Non-St | rategic | To be | Total by |
|----------------|-------------------------|---------|----------|---------|------------|-----------|
| | Deployed | Reserve | Deployed | Reserve | Dismantled | Country |
| United States | 1,950 ⁸ | 2,850° | 200 | - | 3,500 | 8,500 |
| Russia | 2,600 ¹⁰ | 3,700 | ~2000 | ~3,300 | - | ~11, 600 |
| China | 185 ¹¹ | 55 | - | - | - | 240 |
| France | 300 ¹² | - | - | - | - | 300 |
| United Kingdom | 120 - 160 ¹³ | 65 | - | - | | 225 |
| Israel | 100 - 200 ¹⁴ | - | - | - | | 100 - 200 |
| India | 60 - 80 ¹⁵ | - | - | - | | 60 - 80 |
| Pakistan | 100 - 110 ¹⁶ | - | - | - | | 100 - 110 |
| North Korea | 0 ¹⁷ | 0 | 0 | 5 - 6 | - | 5 - 6 |
| Total | ~5,550 | 6,670 | 2,200 | 3,305 | 3,500 | ~21, 240 |

World Nuclear Weapons Stockpiles 2011

Sorce: British American Security Information Council (BASIC) Nov. 2011

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.

According to the 2010 yearbook of the Stockholm International Peace Research Institute (2010 <u>Yearbook</u>), published in June 2010, Russia and the United States have a large quantity of nuclear warheads (maybe 22,000 units) and there exist 7 other countries in the same condition, namely: Great-Britain, France, China, Israel, India, Pakistan and possibly North Korea.

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

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

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

Brazil has refused to sign such additional protocol and even prevented IAEA inspectors from performing inspections on a part of the program deemed to be a scientific secret. Moreover, Brazil in association with Argentina has an oversight agency that jointly controls the production of fissile



material, the ABACC (Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials), and verifies the peaceful use of nuclear materials produced by both countries.

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



X – A Few 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:

- Canada NRU, operating since 1957, around 50% of world production;
- Netherlands HFR at Petten- 1961, 25 % (shut down);
- South Africa Safari at Pelindaba, 1965, 10 %;
- Belgium BR2 at Mol 1961, 9%;
- France Osiris at Saclay 1965, 5%.

South Africa's reactor (Safari) was converted in 2009 to use low-enrichment uranium only (less than the usual 20% of such type of reactor), in an attempt to reduce the costs of this activity.

Brazil is not self-sufficient in radioisotope production for nuclear medicine - and every year imports US\$ 32 million worth of molybdenum 99, from which the radiopharmaceutical used in exams is obtained. With the outage of the Canadian reactor, Brazil has met part of its demand by purchasing the radioisotopes it needs.

A solution to the problem would be the Brazilian Multipurpose Reactor – RMB. Its implementation (around 5 years at a cost of 500 million dollars) could meet this demand and that of other industries in Brazil, seeing that, besides radioisotope production, the RMB would be used in irradiation tests of materials and fuels and in research with neutron beams. This project would contribute to the development of a scientific and technological framework essential to support the expansion of the Brazilian nuclear program.

According to Prof. José Augusto Perrotta – Assistant to the President, National Nuclear Energy Commission – CNEN, the project is currently in the conception phase of the RMB reactor. In parallel, ground investigations of the selected site are under way. 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.



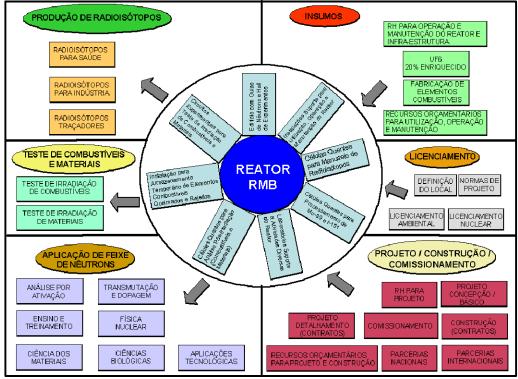


Image - Prof. José Augusto Perrota

At present, Brazil has only four cyclotrons in operation, in São Paulo, Rio de Janeiro, Belo Horizonte and Recife, 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. The advantage of iodine-124 over fluorine-18 – the most extensively used radioisotope in PET examinations – is its longer half-life, 4.2 days. For comparison, that of fluorine-18 is less than two hours. This means that the use of iodine-124 can help democratize the access to PET, in that it allows the examination to be conducted at sites more distant from production centers. Due to this radioisotope's longer half-life, the logistics of distribution is also significantly facilitated.





IEA-R1m -CNEN/IPEN -São Paulo- Brazil



IPEN/MB-01 - São Paulo - Brazil

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 combatting 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 has no access to potable water, and water **cleaning and desalination** in such areas (especially in Africa and Asia) 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.

lonizing 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.

In agriculture, its main use is food irradiation, especially fruits and vegetables as a preservation means, as recommended by the WHO – World Health Organization. The processes vary by food



type, but the objective is to delay fruit ripening, destroy fungi and harmful bacteria, and prevent diseases and several insects. Another use is fertilizer conservation (peat).



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 |
| com | 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



XI – Decommissioning

Every power plant, whatever its fuel, is designed for a specific useful lifetime, after which it will be no longer economical to operate it.

The term decommissioning is used to describe all administrative and technical actions associated with the end of the operating life of a nuclear facility and its subsequent dismantling to facilitate the appropriate removal of regulatory controls ("permit to decommission").

These actions involve decontamination of structures and components, dismantling of components, demolition of buildings, remediation of any soil contamination and removal of resulting wastes.

All over world there exist around 560 nuclear electricity generation plants which are or have been in operation. Out of these, 133 are in permanently shut down status and at some stage of decommissioning.

Around 10% of these shut down plants have already been completely decommissioned, including 8 reactors of more than 100 MWe each. A large number of other facilities and plants for uranium extraction and enrichment, fuel fabrication, research facilities, reprocessing, and laboratories have been shut down and decommissioned.

The table below shows the reactors shut down for political reasons. According to the WNA, they have been or will be decommissioned. Here we are not listing eight (Kruemmel, Brunsbuettel, Biblis A and B, Isar 1, Neckarwestheim 1 and Phillipsburg 1) in Germany because they can still work sometimes.

| F | Reactors closed prer | naturely for polit | ical reasons (2 | 25 units) | |
|------------|----------------------|--------------------|-----------------|--------------------|---------------------|
| Country | Reactor | type | MWe net | years of operation | date of clousure |
| Armenia | Metsamor 1 | VVER- 440/V270 | 376 | 13 | 1989 |
| Bulgary | Kozloduy 1-2 | VVER- 440/V230 | 408 | 27, 28 | dez/02 |
| Bulgary | Kozlodu y 3-4 | VVER- 440/V230 | 408 | 24, 26 | dez/06 |
| France | Super Phenix | FNR | 1200 | 12 | 1999 |
| Cormony | Greifswald 1-4 | VVER- 440/V230 | 408 | 10, 12, 15, 16 | 1990 |
| Germ an y | Muelheim Kaerlich | PWR | 1219 | 2 | 1988 |
| | R hein sberg | VVER-70/V210 | 62 | 24 | 1990 |
| | Caorso | BWR | 860 | 12 | 1986 |
| Italy | Latina | GCR | 153 | 24 | 1987 |
| | Trino | PWR | 260 | 25 | 1987 |
| Lithuania | Ignalina 1 | RBMK LWGR | 1185 | 21 | 2005 |
| Littiuaina | Ignalina 2 | RBMK LWGR | 1185 | 22 | 2009 |
| Slovakia | Bohunice 1 | VVER- 440/V230 | 408 | 28 | dez/06 |
| 510Vakia | Bohunice 2 | VVER- 440/V230 | 408 | 28 | dez/08 |
| Suce dia m | Barseback 1 | BWR | 600 | 24 | n ov/99 |
| Sweden | Barseback 2 | BWR | 600 | 28 | m ai/05 |
| | Chernobyl 1 | RBMK LWGR | 740 | 19 | dez/97 |
| Ukraine | C hernobyl 2 | RBMK LWGR | 925 | 12 | 1991 |
| | C hernobyl 3 | RBMK LWGR | 925 | 19 | dez/00 |
| USA | Shoreham | BWR | 820 | 3 | 1989 |



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

| | Reactors closed after an accident (11 units) | | | | | |
|-------------|--|-------------|--------|-----------------------|--------------------|--|
| Country | Reactor | type | MWenet | years of operation | date of closure | Reason |
| Germany | Greifsweld 5 | WER440/V213 | 408 | 0,5 | rov/89 | Partial melting of the core |
| Cantaly | QundrenmingenA | BWR | 237 | 10 | jan/77 | Operational Error on shutdown of the reactor |
| | Fukushima Daiichi 1 | BWR | 439 | 40 | mar/11 | Matting Carefor loss of cooling |
| haven | Fukushima Daiichi 2 | BWR | 760 | 37 | mar/11 | Matting Carefor loss of cooling |
| Japan | Fukushima Daiichi 3 | BWR | 760 | 35 | mar/11 | Matting Carefor loss of cooling |
| | Fukushima Daiichi 4 | BWR | 760 | 32 | mar/11 | destruction by Hydrogen explosion |
| Slovakia | BohuniceA1 | Prot GOHWR | 93 | 4 | 1977 | Reactor damaged by the fuel load error |
| Spain | Vandellos 1 | GCR | 480 | 18 | jun/90 | Turbinefire |
| Switzerland | StLucens | ExpGCHWR | 8 | 3 | 1966 | Metting Care |
| Ukraine | Chemobyl 4 | RBMKLWGR | 925 | 2 | abr/86 | Fire and Melting Care |
| USA | Three Mile Island 2 | PWR | 880 | 1 | mar/79 | Partial melting of the core |

There exist other 97 reactors in the world that will be decommissioned as they have reached the end of their operational life.



XII – Conclusions

Despite the increasing anti-nuclear sentiment after the Fukushima nuclear plant accident, nuclear technology remains the cheapest and most efficient source of energy, as reported in July 2011 by financial consultant firm KPMG. Notwithstanding, they understand fossil sources will continue to play a major role in global energy supply, at the cost of a strong increase in CO2 emissions, which nuclear energy alone will be able to offset by means of plants capable of operating for up to 60 or 80 years, with much cheaper fuels.



This view is shared by the IEA (OECD's Energy Agency) International in its November 2011 report - World Energy Outlook, according to which 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, 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 Director of the IAEA, Yukiya Amyear, 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 will be 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).

Fukushima showed the incredible resistance of the disaster-hit nuclear power plant. It was capable of resisting a planetary event much above its design basis. The organization capacity of the Japanese government and people was capable of evacuating, in a timely manner, the population that could be in danger due to radiation. A comparison can be made with the 1976 Three Mile Island accident in the USA, one of the greatest in nuclear history, with no deaths, or injuries or no illnesses. The same cannot be said for other accidents in electricity generation over time. (See WNA - Environment, Health and Safety in Electricity Generation). No other industry can portray the indicators shown by nuclear plants on accidents over the past 50 years of operation.



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.

The Fukushima accident, whose effects we still live with today, will bring forth a deep technical analysis of the event and will lead to many other lessons applicable not only to nuclear plants of the BWR type, but also to other plants in operation, as well as those under design and/or construction, in enhancing safety through a process of continuous improvement.

Demands for immediate actions, after the Fukushima accident, to the effect of shutting down operating plants or suspending projects under way are triggered by the catastrophist climate that has prevailed in media reporting of the event, with strong influence on public opinion. Such demands are, sometimes, precipitated by reasons of a political or ideological nature, which, even if lawful in democratic societies, are not backed by any technical rationale.

It is important that society and governments take no rash decisions moved by the heat of emotion or ideological opportunism, which will come to harm the very societies they are supposedly trying to protect.

If nuclear energy is to be part of the future, the industry must overcome the great challenges ranging from difficulties in the supply of materials such as large forgings to the lack of skilled manpower in nuclear engineering and other related disciplines, besides the ageing of difficult to replace specialists.

The interest in developing new nuclear plants has been growing around the world. In addition to those countries that currently run nuclear power plants, 65 others have expressed interest in nuclear electricity generation, mainly if one takes into account the amount of electricity that can be generated without more pollutant emissions and in a very limited physical space. The use of nuclear energy for hydrogen production, electric transport systems, desalination or other nontraditional applications will bring additional demands to bear on the design of advanced reactors, which will be smaller, less expensive, more simplified and planned to run on more efficient thermodynamic cycles.

The technical workforce, with accumulated knowledge and experience, is companies' most important asset, especially in the nuclear area. Today, there exists a one-generation gap in terms of nuclear education which the industry is challenged to overcome. Several countries are seeking to train new engineers and technicians, as indicated by the initiative of the U.S. Department of Energy - DoE, which has set up a university program in nuclear energy where, among other actions, students are offered scholarships and fellowships of up to 150 thousand dollars. THE NRC – Nuclear Regulatory Commission also has a similar program.

Between 2003 and 2009 an expansion occurred in the number of United States undergraduates and graduates specializing in nuclear energy:



| | B.S. degrees awarded | M.S. degrees awarded | Ph.D degrees awarded |
|------|-------------------------|-------------------------|-------------------------|
| 2009 | 395 | 233 | 87 |
| 2008 | 454 | 260 | 127 |
| 2007 | 413 | 227 | 89 |
| 2006 | 346 | 214 | 70 |
| 2005 | 268 | 171 | 74 |
| 2004 | 219 | 154 | 75 |
| 2003 | 166 | 132 | 78 |

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 is the most promising option.

Carbon free sources should not be viewed as competing with one another, but as partners in facing the challenge to provide the world with clean and abundant energy.



XI – Major Sources of Information

- IAEA 2010, Country Nuclear Power Profiles
- Nucnet several
- Nucleonics Week e NuclearFuel several
- IAEA PRIS <u>http://www.iaea.org/programmes/a2/index.html</u>
- WNA World Nuclear Association <u>- http://www.world-nuclear.org/</u> <u>http://world-nuclear.org/NuclearDatabase/Default.aspx?id=27232</u>
- NRC- Nuclear Regulatory Commission –
- <u>http://www.nrc.gov/reactors/new-reactors/col/new-reactor-map.html</u>
- INB Indústrias Nucleares do Brasil <u>http://www.inb.gov.br</u>
- Empresa de Pesquisa Energética EPE <u>http://www.epe.com.br</u>
- IAEA Publications <u>http://www.iaea.org/Publications/Booklets/NuclearPower/np08.pdf</u>
- NRU: http://www.nrucanada.ca/en/home/projectrestart/statusupdates/nrustatusupdate25.aspx
- Bélgica <u>http://www.ce2030.be/public/documents_publ/CE2030%20Report_FINAL.pdf</u>
- WNN: <u>http://www.world-nuclear-ews.org/NN Nuclear plans forge ahead 160609.html</u> e <u>http://www.world-nuclear.org/info/inf122 heavy manufacturing of power plants.html</u>
- DOE: <u>http://www.eia.gov/forecasts/ieo/pdf/0484(2011).pdf</u>
- Mapas: <u>http://www.insc.anl.gov/pwrmaps/</u>
- TNP : <u>http://www.un.org/events/npt2005/npttreaty.html</u>
- European Nuclear Safety Training and Tutoring Institute : <u>www.enstti.org</u>
- Energy Electricity and Nuclear Power Estimates for the Period up to 2030 -<u>http://bipartisanpolicy.org/library/report/task-force-americas-future-energy-jobs</u>
- Nuclear Energy Technology Roadmap <u>http://www.iea.org/papers/2010/nuclear_roadmap.pdf</u>
- Deployed warheads SIPRI Year Book 2011 <u>www.nea.fr/html/rwm/wpdd</u>
- <u>WWW.word-nuclear.org/how/decomissioning.html</u>
- http://www.friendsjournal.org/earthquake-tsunami-and-nuclear-power-
- Exelon Corp <u>http://www.exeloncorp.com/powerplants/peachbottom/Pages/profile.aspx</u>
- Radiation : <u>http://microsievert.net/</u>
- Radiation risk and realities <u>- http://www.epa.gov/rpdweb00/docs/402-k-07-006.pdf</u>
- WNA Nuclear Radiation and Health Effects <u>- http://world-nuclear.org/info/inf05.html</u>
- WNA Environment, Health and Safety in Electricity Generation <u>http://www.world-nuclear.org/info/default.aspx?id=15882&terms=Severe%20Accidents%20in%20the%20Energy%20Sector</u>