MYCLE SCHNEIDER CONSULTING
Independent Analysis on Energy and Nuclear Policy

45, ALLÉE DES DEUX CÈDRES
91210 DRAVEIL (PARIS)
FRANCE

TÉL: 01 69 83 23 79
FAX: 01 69 40 98 75
E-MAIL: mycle@orange.fr

Nuclear France Abroad

History, Status and Prospects of French Nuclear Activities in Foreign Countries

Mycle Schneider
International Consultant on Energy and Nuclear Policy

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About the Author

Mycle Schneider works as independent international energy nuclear policy consultant.

Between 1983 and April 2003 Mycle Schneider was executive director of the energy information service WISE-Paris. Since 2000 he has been an advisor to the German Ministry for the Environment, Nature Conservation and Reactor Safety. Since 2004 he has also been in charge of the Environment and Energy Strategies Lecture of the International Master of Science for Project Management for Environmental and Energy Engineering at the French *Ecole des Mines* in Nantes, France. In 2007 he was appointed as a member of the International Panel on Fissile Materials (IPFM), based at Princeton University, USA (www.fissilematerials.org).

In 2006-2007 Mycle Schneider was part of a consultants' consortium that assessed nuclear decommissioning and waste management funding issues on behalf of the European Commission. In 2005 he was appointed as nuclear security specialist to advise the UK Committee on Radioactive Waste Management (CoRWM).

Mycle Schneider has given evidence and held briefings at Parliaments in Australia, Belgium, France, Germany, Japan, South Korea, Switzerland, UK and at the European Parliament. He has lectured extensively on four continents including at Carlton University, Ottawa (Canada), Tsinghua University (China), Freie Universität, Berlin (Germany) and Ritsumeikan University, Kyoto (Japan).

Between 1998 and 2003 he was an advisor to the French Environment Minister's Office and to the Belgian Minister for Energy and Sustainable Development.

Mycle Schneider has provided information and consulting services to a large variety of clients including the International Atomic Energy Agency (IAEA), Greenpeace International, the International Physicians for the Prevention of Nuclear War (IPPNW), UNESCO, Worldwide Fund for Nature (WWF), the European Commission, the European Parliament's General Directorate for Research, the Oxford Research Group, the French National Scientific Research Council (CNRS), & the French Institute for Radiation Protection and Nuclear Safety (IRSN).

In 1997 he was honoured with the *Right Livelihood Award* ("Alternative Nobel Prize") together with Jinzaburo Takagi for their work on plutonium issues (http://rightlivelihood.org/recip.htm).

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Contents

Summary

French nuclear development started with the nuclear weapons research efforts during the Second World War in the UK, Canada and the U.S.. At least five French scientists (Halban, Kowarski, Auger, Guéron, Goldschmidt) played a significant role in the development of the first nuclear weapons. Auger chaired the physics department at the Montréal Laboratories, the largest nuclear weapon effort outside the U.S. during the war, and Kowarski headed design and construction of the ZEEP pile, the first nuclear reactor to go critical outside the U.S., in 1945 in Chalk River, Canada.

France established its own Atomic Energy Commission (CEA) in 1945 with the task to develop nuclear science and technology. The French nuclear system never developed separate civil and military fuel chains. On the contrary, the design of the system was meant to optimize research, development, design, construction and operation of nuclear facilities so that the civil sector would profit from military advances and vice-versa. Also, organizations were set up to deal with both areas, the CEA in the beginning, later also COGEMA (now AREVA NC) to provide and manage nuclear materials for civil and military uses.

France was skeptical of early European integration efforts like the EURATOM Treaty, because it was concerned about loosing its sovereignty over nuclear decision-making. Similar concerns pushed General De Gaulle in 1958 to abandon a well-advanced trilateral nuclear weapon-related project with Germany and Italy.

On the other hand, France has started early to share nuclear technology with other countries. By the end of the 1960s it had already signed nuclear cooperation agreements with at least 25 countries. Many of these countries received not only civil nuclear assistance, including geo-politically highly problematic countries like Israel, Iraq, India, Pakistan and South-Africa.

France provided Israel with know-how, materials and manpower to build its Dimona nuclear weapons complex, including the reactor and a reprocessing facility. Iraq's Saddam Hussein was provided with a large research reactor and the highly enriched, weapons grade uranium fuel to operate it. Israel bombed and destroyed the facility before it went critical. India received far reaching assistance to develop fast breeder technology, a reactor type that generates weapons grade plutonium as a by-product.

In September 2008, even before the U.S.-Congress had passed the U.S.-India deal, France signed a new cooperation agreement with India. It needed strong U.S. government pressure under President Carter[1] for France in 1978 to abandon the project to provide Pakistan with plutonium separation technology. However, some reprocessing know-how and hardware had already been transmitted. In the 1980s Pakistan's Embassy in Paris turned into the seat of a vast trafficking of materials and parts for nuclear facilities.

The development, orientation, design and implementation of French energy and nuclear policy, inside and outside the country, is not carried out by elected politicians but by a very small group of elite technocrat-engineers from the state *Corps des Mines*, originally established in 1810. Most of the key positions linked to nuclear policy are attached to the *Corps des Mines*, from key ministerial advisor positions to top industry executives (AREVA, TOTAL), from the president of the national Bureau of Geological and Mining Research (BRGM) to the Director General of the National Radioactive Waste Management Agency (ANDRA) and the head of the Nuclear Safety Authority (ASN), *all* are members of the *Corps des Mines*. This official state body, that only counts about 500 members or former members, occupies also strategic nuclear positions in foreign countries, including the president of AREVA Inc. in the U.S. and the nuclear counselor at the French Embassy in the U.K..

The lasting omnipresence of this elite network, which has never been under any kind of public scrutiny or operated under democratic rules, has guaranteed a remarkable constancy in French nuclear policy over the last six decades.

[1] Carter had nuclear training and had hands-on nuclear experience; for example, he participated in the clean-up of the Canadian NRX reactor meltdown in 1952.

Today France ~~is~~ clearly dominates the international nuclear sector. AREVA, majority government owned, has been built into a powerful industrial group with over 65,000 people, manufacturing facilities in 43 countries, and a sales network in more than one hundred. AREVA covers all aspects of the nuclear supply and service system and holds participations in a large number of companies around the planet.

AREVA's world market share in the front-end activities (see figure 3) are respectively 20-25% in uranium mining, 25-30% in uranium conversion, 20-25% in uranium enrichment and 30-35% in low enriched uranium fuel fabrication. In reactor building and servicing the market share is 20-25% while AREVA is entirely dominating the backend activities spent nuclear fuel reprocessing and uranium-plutonium mixed oxide fuel (MOX) fabrication with respective market shares of 70-75% and 65-70%.

AREVA owns shares in uranium mines in Canada, Kazakhstan and Niger and, with the takeover of the Canadian uranium company Uramin in 2007, it has added sites in Namibia, South Africa and the Central African Republic. The mining activities have led to numerous environmental problems in the past. AREVA's role in Niger has triggered an armed conflict between the Niger national army and the Tuareg people who not only protest~~s~~ environmental and health effects, but also claim an appropriate return from the exploitation of uranium mines on their land.

Uranium conversion and enrichment in Russia, especially of uranium reprocessed at the French La Hague site raises questions over selected waste management schemes. It is clear that a large portion of waste materials remains in Russia.

Uranium enrichment in France is carried out by the international EURODIF group, of which AREVA NC holds 60%. Until today 10% of the EURODIF capital is held by the Iranian State. In other words, Iran makes considerable amounts of money in dividends – tens of millions of euros per year – through an industrial activity that led to international sanctions when carried out in Iran.

AREVA NP is currently the largest reactor builder in the world. However, the two EPR (European Pressurized Water Reactor) units officially under construction have turned into anything but positive demonstration plants. The Finnish Olkiluoto-3 project, after three years construction, is officially about three years behind schedule and some €1.5billion (50%) over budget. The French Flamanville-3 project, after one year construction, is officially already €0.8billion (20%) over budget. But while AREVA's CEO Anne Lauvergeon has stated that the building site is one year behind schedule, EDF pretends that the project is still on time.

AREVA reportedly has also sold two EPRs to China. The Taishan project will get underway in 2009. Any statement on the status of the project would be premature.

AREVA NC is the world leader in spent fuel reprocessing. However, tonnage under contract from foreign clients is limited to a couple of months of capacity of the La Hague plants. Most of the nuclear countries in the world have never embarked upon, or have since abandoned, reprocessing. AREVA NC is left with its domestic client EDF.

Over the past two years, the current French administration has negotiated a number of nuclear cooperation agreements with newcomer countries like Algeria, Jordan, Libya, Morocco, Tunisia and the United Arab Emirates; major new nuclear cooperation agreements were signed with Brazil, China, India, and South Africa. For the wannabe nuclear players, it is very unlikely that they will implement fission power programs any time soon, if ever. None of the newcomer countries have proper nuclear regulations, regulators, maintenance capacity, or the skilled workforce in place to run a nuclear plant.

Furthermore, their electricity grids are entirely inappropriate to handle the increased power load from a large nuclear plant. The idea of encouraging and promoting nuclear energy seems even more surprising in countries with blatantly obvious democratic ~~cy~~ deficits and beset by armed rebel groups, many of whom have demonstrated stunning levels of menace towards their fellow citizens.

In the meantime, Sarkozy's announcement politics complement perfectly the international nuclear industry's massive PR campaign promoting nuclear power as being 'back on the global energy agenda'. The current French administration pursues the traditional approach of 'equal distribution' in the nuclear field. Whether nuclear technology or conventional weapons, French geo-politics have always attempted to serve upcoming 'needs' in a non-discriminatory manner, if necessary, to so-called 'rogue states' like Libya, and on both sides of a potential conflict line: eg Israel and Iraq, India and

Pakistan…etc. Meanwhile the strategy risks contributing to the steady erosion of the international non-proliferation regime.

French nuclear companies estimate that up to-2020 there is a world market for 140 GW (EDF) and to 2030 a potential of 170 GW to 500 GW (AREVA) of new build nuclear capacity in the world. The Atomic Energy Commission (CEA) evaluates the world market at 200 GW to 400 GW but is prudent enough not to indicate any timeframe. EDF and AREVA hope to recover a big chunk of the hypothetical market.

In 2008, for the first time in nuclear power history, no new reactor went online; three units were shut down, the overall installed capacity decreased compared to the previous year and the nuclear share in the total commercial electricity generation dropped another percent point to 14%. A quarter of the 44 units listed by the IAEA as "under construction" (as of January 2009) have been listed there for over 20 years. The industry has great difficulties to find the skilled workers it needs, even for the operation and maintenance of currently operating units. In addition, fabrication facilities for large components like pressure vessels, steam generators and turbine trees are scarce.

The French nuclear industry has achieved the leading role worldwide in nuclear manufacturing and servicing. This capacity, that most likely will have a very modest effect on world energy and climate policy, is being used intensively for geo-political purposes. In generously offering nuclear technology to a large number of newcomer countries, France would like to demonstrate that is treating all countries along the lines, "we have it, why shouldn't you have it". As in the past, it is highly unlikely that a significant share of cooperating countries will actually develop operational nuclear power programs, but the French "cooperative" attitude allows for the short-term transfer of nuclear know-how to a large number of people and institutions representing a significant number of countries. This will necessarily lead to a ‘banalization’ of nuclear know-how, facilities and materials that is highly counter-productive to any serious non-proliferation effort.

Historically, France has a largely negative non-proliferation record. It has spread nuclear technology, including know-how on special nuclear materials and weapons manufacturing, to, with certainty, a number of countries. The combination of the Nuclear Suppliers Group's September 2008 decision to abandon Full Scope Safeguards requirements for non-NPT-signatory countries with the French international nuclear commerce ambitions raises a number of urgent questions the international community should not evade elude.

Introduction

France has established a full-scale nuclear program that comprises the entire fuel chain from uranium conversion to spent fuel and nuclear waste management. France is currently the most active country in the attempt to extend the use of nuclear power worldwide, in particular beyond the 31 countries that currently generate nuclear electricity.

The French nuclear program started abroad. French nuclear scientists participated in the US Manhattan Project and, in return, were awarded the right to take nuclear secrets "back home". The French nuclear weapons program started immediately after the Second World War. The fact that France never established separate civil and military nuclear fuel systems, as in other countries, allowed for their mutually interdependent advancement in terms of knowledge and infrastructure development.

The French nuclear sector, at the political, administrative and industrial levels, whether public and private, is controlled by a technocratic elite that permits, and indeed promotes, the design, development and implementation of long-term strategies largely beyond democratic oversight.

France has used nuclear technology assistance as a geopolitical tool from the very earliest stages and nuclear cooperation – with or without an official cooperation agreement – has been provided to a large number of countries.

France has today become a dominant player in the world nuclear industry. The main organizations involved, AREVA, EDF and CEA, provide nuclear education and training, nuclear fuel services, reactor construction and maintenance, as well as spent fuel and waste management services for many countries.

Outside France, AREVA operates fuel fabrication facilities in Belgium, Germany and the US. In addition, AREVA is a partner, with US firm URS Washington Group, and British company AMEC, in the Nuclear Management Partnership that now manages the Sellafield nuclear reprocessing, plutonium and waste storage, and MOX fuel fabrication plants in the UK.AREVA has acquired stakes in uranium mines in several countries and has established uranium enrichment agreements with other key players in the field (such as URENCO, USEC, TENEX). EDF has taken over or acquired participation in major foreign nuclear operators. AREVA and EDF are involved in reactor building projects in China and Finland. AREVA is also building a plutonium fuel (MOX) fabrication facility in the US.

The International Atomic Energy Agency's Director-General has stated that over 50 countries contacted his organization and demonstrated an interest in nuclear energy technology. The French nuclear industry is counting on seizing a significant share of the world market for ‘new build’.

The objective of this paper is to analyze past, present and future French nuclear activities outside French borders. In terms of the current situation, this report will provide an overview of ongoing French activities in capacity-building, reactor construction and fuel services and shed light on prospects for a substantial enlargement of such activities within the 2020-2030 timeframe.

Historical Aspects

The background of nuclear development in France and its international links

"How it all began in Canada"[2]

Bertrand Goldschmidt
French Manhattan Project Scientist

The French nuclear program originated with the participation of French scientists in the early US and UK nuclear weapons projects. In 1940 the French government acquired all 185 kilograms of the world's then known stock of 'heavy water' from Norway, and succeeded in reserving all future production for France. Two French scientists, Hans von Halban and Lew Kowarski[3] initially took the heavy water to the UK and proved that fission was possible on the basis of natural uranium. In October 1942 Halban and his team moved to Canada and started a large nuclear research project at the University of Montréal. Three other French citizens worked on the British/Canadian nuclear weapon efforts during the war: Pierre Auger directed the physics department at the Montréal Laboratory, Jules Guéron had a key role in chemical sciences and Bertrand Goldschmidt, a nuclear chemist, would play a significant role in both the US and French nuclear programs. But the US government, on security grounds, kept the Montréal team from obtaining key information about the Manhattan Project and from obtaining scarce strategic materials such as uranium, heavy water and plutonium.

In 1944 Kowarski was nevertheless entrusted by the Canadian government with building the ZEEP pile at Chalk River, Ontario, which in September 1945 became the first nuclear reactor to go critical outside the US.

Auger, Goldschmidt and Guéron decided to inform General Charles De Gaulle of nuclear developments in North America and their relevance to future world politics. On 11 July 1944 De Gaulle spent 15 minutes with the Canadian representatives of *La France Libre* during a fleeting visit in Ottawa. Guéron was given three minutes to talk to De Gaulle alone. When the three shook hands a few minutes later, De Gaulle said to Goldschmidt: "Thank you, I have very well understood".[4]

Goldschmidt, had meanwhile met Glenn Seaborg's team, in charge of plutonium separation in under the Manhattan Project. He later stated:

> Taking advantage of my experience with Seaborg's group in 1942, I was able, with a small team of Canadian chemists, to establish the outline of the first solvent extraction process for plutonium in 1945, thus demonstrating for the first time the relative ineffectiveness of the policy of secrecy in such a specifically sensitive field as the reprocessing of irradiated fuels and paradoxically between close allies during the war.[5]

This was the beginning of the "French way" in international nuclear policy. In contrast to other countries, France has always been quite generous with information, technology and nuclear materials transfers.

The civil-military connection

In 1945 the French government created the Atomic Energy Commission (CEA) with the explicit, though secret, task of undertaking the French nuclear bomb program, as well as civilian nuclear applications. The CEA has since consolidated the military-civilian nuclear connection, both domestically and internationally. Even today, the Commission's military applications and civil energy departments employ the same number of people, about 4,500 each. The CEA has a wide area of

[2] Bertrand Goldschmidt, "How it All Began in Canada: The Role of the French Scientists", presentation at the Special Symposium "50 Years of Nuclear Fission", Canadian Nuclear Society, 5 June 1989
[3] Halban, of Austrian origin, and Kowarski, of Russian origin, were only naturalized French in 1939.
[4] "Je vous remercie, j'ai très bien compris". Source: Bertrand Goldschmidt, "Le Complexe Atomique – Histoire politique de l'énergie nucléaire", 1980, pp. 71-72
[5] Bertrand Goldschmidt, op.cit.

responsibility in nuclear matters, ranging from fundamental research in physics to research and development for radioactive waste management. Its Direction des Applications Militaires (DAM) was responsible for warhead testing at Moruroa in the South Pacific. Its former subsidiary COGEMA (Compagnie Générale des Matières Nucléaires), now AREVA NC, is responsible for the production and maintenance of nuclear materials, including plutonium. The CEA built the plutonium production plants at Marcoule and La Hague.

The French civil nuclear program has profited hugely from the military program and vice versa. The 1973 CEA annual report explains the "French approach"*:*

> The CEA must, within the framework of a rigid budget and strictly limited possibilities of expansion, adapt the production of military nuclear material to rapidly changing needs by taking advantage of technical progress and civilian programs (which themselves have greatly benefited from military programs) in order to limit the costs.

One of the consequences was the development of a national gas-graphite reactor technology that was supposed to provide electricity for the grid and plutonium for weapons. The first commercial-size reactors at Chinon, initially called EDF-1, -2 and -3,[6] were in fact at least partially and periodically used for military purposes. Thus it was not only national pride that made the abandoning of this reactor technology in favor of the American Westinghouse technology particularly painful. Unlike the United States, which has attempted, to a large extent, to separate civil and military uses of nuclear energy, France has never divorced the administration of nuclear energy from that for nuclear weapons. As the latest French official report on the protection and control of nuclear materials states: "In fact, France is a civil and military nuclear power but does not have two separate [fuel] cycles."[7]

The historical French role in international nuclear strategies

In the 1950s a number of influential nuclear and defense officials negotiated a trilateral agreement between France, Germany and Italy to jointly develop a nuclear force. Key drivers were the CEA under Pierre Guillaumat, and the then German Minister for Nuclear Affairs (and later Minister of Defense) Franz-Josef Strauss. Guillaumat stated: "It is me who informed my minister. The President of the Council (Prime Minister) was not informed. This was only on the level of the Defense Ministry".[8] However, Guillaumat considered the agreement "non-applicable" because it purported to commit the CEA, which was under direct responsibility of the President of the Council.[9]

France was also afraid of losing its nuclear sovereignty and leading edge in nuclear research and development in the European integration process. The French government for instance suggested the inclusion of a joint property clause for special fissile materials in the 1957 EURATOM Treaty, which gave special rights to the two European nuclear weapon states, France and the UK, although France had not yet fully joined the elite nuclear weapons club of nations (it would in 1960), and the UK would not accede to EURATOM until 1973, after it joined the European Economic Community, now called the European Union. While legally the EURATOM Supply Agency has ownership of all enriched uranium and plutonium in the EU[10], in industrial reality this is not the case.

After De Gaulle took power in 1958 he terminated the continuing Franco-German-Italian nuclear weapons negotiations and pursued the sovereign French way. He left no doubt about his intentions in a

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[6] They were later renamed Chinon-A1, -A2 and –A3. EDF was never comfortable with the nuclear weapons link.

[7] BSNMS, "Rapport sur l'application des dispositions de la loi du 25 juillet 1980 sur la protection et le contrôle des matières nucléaire, Année 2007", HFDN, Ministère de l'Industrie, 2008

[8] Interview with the author and Georg Blume, Paris, 10 September 1986, published as "Interview avec Pierre Guillaumat, le constructeur de la bombe française", Damocles, Lyon, 4th Trimester 1995

[9] The triangle nuclear weapon project appears all the more surprising since the German government had renounced the acquisition of nuclear weapons in a letter by Chancellor Adenauer attached to the 1954 Paris Agreements that created in particular the Western European Union, a (not very fruitful) attempt to establish a framework for joint European defense efforts.

[10] Article 52 b) stipulates: "An Agency is hereby established; it shall have a right of option on ores, source materials and special fissile materials produced in the territories of Member States and an exclusive right to conclude contracts relating to the supply of ores, source materials and special fissile materials coming from inside the Community or from outside".

speech to the Ecole Militaire on 3 November 1959, stating that it is "indispensable that it [the French defense system] is ours, that France defends itself by itself, for itself and in its own way".[11] On 13 February 1960 the first French nuclear weapon was detonated exploded in the Sahara desert in what was then French Algeria.

The French Nuclear Establishment

The development, orientation, design and implementation of energy and nuclear policy in France is carried out by a very small, elite group of technocrat-engineers from the state *Corps des Mines*. The government, in particular the Prime Minister and the President of the Republic, retains formal executive power over nuclear decision-making, but they are totally dependent on advice from the *Corps des Mines.* Decisions in the nuclear realm are hardly ever based on decisions by, or even consultations with, Parliament.

The *Corps des Mines* was established in 1810, its members recruited exclusively from the military *Ecole Polytechnique.* In the beginning its role was to implement the mining code, issue mining concessions and permits and train professionals in this area. 'Mining' was defined as encompassing the three key ingredients for war: coal, steel and gunpowder.

In 1940 the Corps des Mines was attached to the Industry Ministry and by 1945 the Corps controlled all departments that dealt with industrial matters, including steel-making. The administration supervising mining activities represented an autonomous entity "governed" by a General Council.[12]

In 1978 access to the *Corps* was opened to a few top graduates from other engineering schools (such as the Ecole Normale Supérieure, the Ecole des Mines de Paris, and the Ecole Nationale Supérieure des Télécommunications). In 2005 there were a total of 271 members of the *Corps des Mines* in public administration.[13] The total number of active members is now around 600.

A 16 January 2009 decree redefined the "particular status of the corps des ingénieurs des mines".[14] The Corps, now attached to the Ministry of Economy (which also has oversight of industry), participates in "the conception, implementation and evaluation of public policies", in a wide range of domains, including the following with particular relevance to the nuclear industry:

• industry and economy;

• energy and primary materials;

• environmental protection, industrial security and public health;

• research, innovation and new technologies; and

• information and communication technologies.

The Corps engineers have a "vocation to occupy positions of direction, supervision and coordination". With the decision to accept nomination to the Corps, members commit themselves to a minimum of eight years of service.

Corps des Mines engineers hold key positions not only in the administrative departments but also in the offices of the Prime Minister and President as well as various ministers' offices. Of Charles De Gaulle's presidential cabinet 2% were members of the *Corps des Mines*, Valéry Giscard d'Estaing's also had 2%, while Georges Pompidou's had as high as 9%.[15]

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[11] Bertrand Goldschmidt, "Le Complexe Atomique – Histoire politique de l'énergie nucléaire", 1980, p.162

[12] Alain Beltran, "Corps des Mines et industrie depuis 1950", 2005

[13] The representation by sector was as follows:
- 240 Economy, Finances & Industry,
- 29 Ecology and Sustainable Development,
- 2 Education

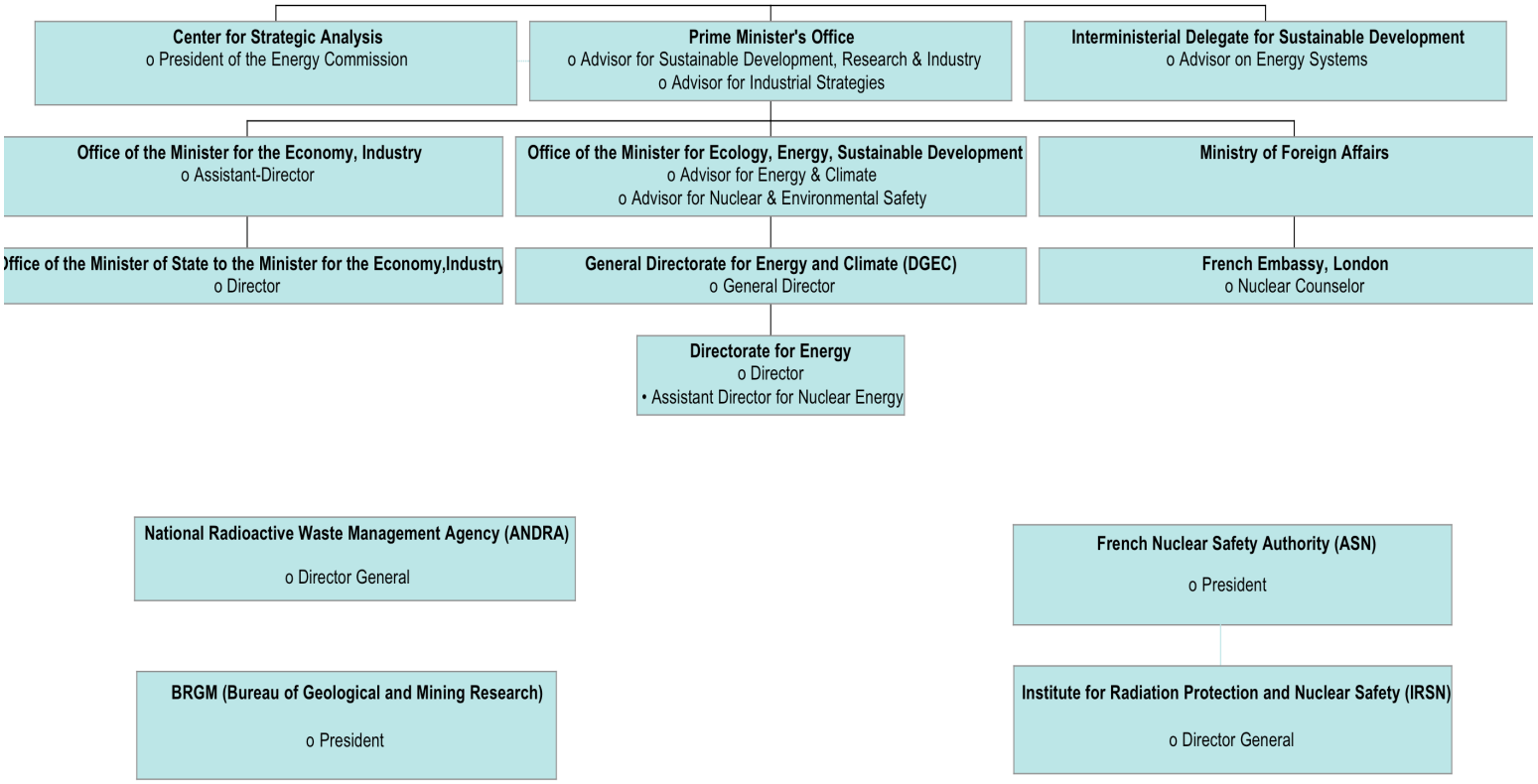
Source: Marie Rey, "Emplois budgétaires 2005 – Volume 2", Ministère de la fonction publique, September 2005

[14] "Décret n°2009-63 du 16 janvier 2009 portant statut particulier du corps des ingénieurs des mines", Journal Officiel, 18 January 2009

[15] An analysis of the share of Corps des Mines engineers in subsequent presidential offices is not available.

Figure 1: The *Corps des Mines* and the French Energy and Nuclear Administration

Positions Held by Members of the Corps des Mines as of January 2009[16]



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"That's why the nuclear power, space and oil policies could be launched on solid ground", stated one of the *Corps'* members in 1982.[17] At the beginning of 2009, members or former members[18] of the *Corps des Mines* held a large share of all top positions in energy and nuclear policy in France (see Figure 1 and Annex 1)[19]. In addition, every time there is a 'Commission', a 'public debate'[20] or any kind of government appointed mission[21] linked to energy and nuclear policy, the *Corps des Mines* quite naturally – at least in its collective mind – supplies the chairperson. These exercises involving public comments have virtually no influence on the decision-making process in the nuclear sector and are designed as part of the communication strategy. In fact, in general decisions are taken prior to the call for public comments. This was for example the case in respect of the Flamanville-3 EPR reactor project in the case of the future Penly-3 EPR project, President Sarkozy simply announced 'his' decision.[22]

[16] See Annex 1 for details and identities.
[17] De Baecque F. et Quermonne J.L., Administration et politique sous la Vème Répubique, PFNSP, 1982, page 112, quoted in Alain Beltran op.cit.
[18] Some members (like AREVA's CEO Anne Lauvergeon in 2004) have chosen to abandon their official "miner" status, in particular when they enter the private or semi-private sector. However, this changes little in the career management of the Corps.
[19] The list in Annex 1 is not comprehensive. There is no public document that shows the current positions of all of the engineers of the *Corps des Mines*.
[20] A series of "public debates" was organized in 1994, chaired by the "miner" Jean-Pierre Souviron. I was invited to a round-table on spent nuclear fuel and waste management. Of the six French representatives, five were *Corps des Mines*, and the sixth a "simple" graduate of Polytechnique.
[21] A 2006-2007 government appointed "Energy Commission" was chaired by Jean Syrota, one of the most influential senior members of the *Corps des Mines*.
[22] Sarkozy declared: "In 2004, I was Minister of Finances and the Economy and I have decided to launch the first EPR and I have chosen Flamanville as the site of construction. And (…) I could take the decision, with the Prime Minister and Christine Lagarde [Minister of Economy] to launch the building site of a second EPR in France". Source: Discours de Monsieur le Président de la République à Flamanville, 6 February 2009

France has increasingly sought to influence international energy policy. The OECD's International Energy Agency (IEA) has remarkably increased its pro-nuclear stance during the term of Claude Mandil as Executive Director (2003-2007). Mandil, former Director for Energy and Primary Materials in the French administration, is a member of the *Corps des Mines*. Industry and utility representatives, diplomats and civil servants have been highly successful in depicting the French nuclear energy program as a great achievement, leading apparently to significant energy independence, reduced dependence on imported oil and as a source of carbon free power.[23]

Elected representatives have always had a minor influence on the development, orientation, design and implementation of energy and nuclear policy in France. Likewise, the politicians' level of understanding of nuclear issues is extremely poor.[24] Nuclear power is essentially under control of the *Corps des Mines*.

On 1 February 2009 the General Mining Council, the governing body of the Corps des Mines, was merged with the General Council on Information Technologies to form the General Council of Industry, Energy and Technologies (CGIET), under the authority of the Minister of Economy who is also its president. However, while ministers change, the "corpsards" remain. The most powerful position in reality is the vice-president of the Council and like two thirds of its members, is an engineer of the *Corps des Mines*.

This state-organized elite has made it possible to push through long-term policy orientations like the nuclear program, beyond electoral influence. The mechanism provides a huge advantage for long-term planning and the implementation of large infrastructure projects. It also constitutes a significant disadvantage for democratic decision-making, and it seriously handicaps significant policy adaptation or reorientation.

Georges Vendryes, who represented France on the IAEA's Board of Governors for 23 years summed up the French exception this way:

> Since forty years the big decisions concerning the development of the French nuclear program are taken by a very restricted group of personalities that occupy key positions in the government or in the top administration of EDF, CEA and the few companies involved in the program. The approach remains unchanged in spite of the change of ministers thanks to the permanence of these personalities that occupy the same position generally for some ten years.[25]

The key characteristic of the system is that specific positions in public administration, economy and industry are assigned to the *Corps des Mines*.[26] When a new government comes in, the *Corps des Mines* presents the relevant minister with a choice of about three member CVs per position, from which he or she can choose his nuclear, energy, industry or other advisors. There are few exceptions to the rule. New positions created fitting into the *Corps* strategy will be filled with "miners" who have been specifically trained for the job. The late Pierre Guillaumat, general administrator of the CEA and Minister of Defense explained:

. Et (…) j'ai pu prendre la décision, avec le Premier ministre et Christine LAGARDE, de lancer le chantier d'un deuxième EPR en France.

[23] This is however only partially true. For example, the per capita oil consumption in France is higher today than in Germany or Italy, the last which has phased out nuclear power 20 years ago. For details see: Mycle Schneider, "Nuclear Power in France – Beyond the Myth", commissioned by the Greens-EFA Group in the European Parliament, Brussels, December 2008, http://www.greens-efa.org/cms/topics/rubrik/6/6659.energy@en.htm

[24] A perfect illustration of the phenomenon was given by the televised debate between the two presidential candidates Nicholas Sarkozy and Ségolène Royal on 2 May 2007. Sarkozy stated France covers half of its electricity by nuclear power, Royal put the figure at 17%, while the real figure for 2006 was 78%. In fact, both politicians mixed up their figures because they don't understand the basics of the concept and thus don't have an idea of the orders of magnitude involved. While Sarkozy gave the official level of energy independence that is largely calculated on the basis of the input of nuclear power, Royal gave the share of nuclear power in the *final energy* mix in France (rather than electricity).

[25] IAEA Bulletin, Autumn 1986

[26] In a similar way, key positions can also be attached to another State Corps, like the *Ponts et Chaussées, Inspecteurs des Finances* or *Poudres*. They have a ranking like the engineering schools (Polytechnique being number one) and the *Corps des Mines* being number one of the Corps.

> It happened so that I had a good relation with the director of the Ecole des Mines for career and Corps reasons and that I said to him: in a year I need a guy who is capable of going towards this or that job. Train him for it! And I have continued to do that afterwards.[27]

Key players like AREVA's CEO and *Corps des Mines* engineer Anne Lauvergeon have first hand experience of executive power. As early as 1988 she became Assistant Secretary General of the General Mining Council. In 1990 she was appointed Special Advisor on International Economy and Foreign Trade to the Presidency and acted as President Mitterrand's Sherpa between 1991 and 1995. Madame Lauvergeon was appointed to the Board of Directors of Suez in 2001.

GDF-Suez recently announced its intention to take a share in the planned EPR project in Penly. The experience of the Director of Strategy is highly valued. *Corps des Mines* engineer Bruno Bensasson has been an official with the Nuclear Safety Authority, then he became consecutively the Nuclear Advisor to the Industry Minister and the Advisor for Environment, Industry and Transport to the President of the Republic, before taking up the position at Suez in September 2007.

The tight control of the energy sector, from technology policy design to implementation strategy, by the *Corps des Mines* has allowed for the basically undisturbed long-term development of the nuclear program. Since the first decision on a major nuclear program was taken in 1974, 14 Prime Ministers have served five Presidents and yet no significant shifts in energy policy are identifiable over the entire period of 35 years. While the consistency of policy beyond electoral concerns can be considered a considerable advantage especially in the case of heavy infrastructural programs, the unique French system has a number of significant disadvantages:

- The decision-making in the energy sector and in particular in the nuclear field is undemocratic. Decisions are taken by a small group behind closed doors and civil society is confronted with communication strategies of large state and corporate entities rather than with a co-decision process.
- The system is entirely exempt from influential corrective elements. Once a decision is taken, there is no way back or out. Examples include the large overbuilding of nuclear capacity[28], the push of the nuclear share to close to 80% in power generation[29], the implementation of the plutonium economy[30] and the broad scale of the energetically and environmentally disastrous electric space heating[31].

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[27] Interview, op.cit.

[28] By the middle of the 1980s it was perfectly clear that the nuclear program was vastly oversized by some 12 to 16 units. But while 138 reactor orders were cancelled in the U.S. at various stages of implementation, absolutely no changes were made to the planning, even when electricity consumption did not even nearly follow forecasts. The reaction was to develop power exports for dumping prices and to stimulate electricity consumption by any possible means (in particular thermal uses like heating, hot water production and cooking).

[29] Under Chatham House rules every French nuclear executive will confirm that they have "gone too far" with the share of nuclear power in the electricity mix. A level of around 60% would make the system much more flexible and economic.

[30] The French nuclear establishment has spent tens of billions of euros in order to separate a substance, plutonium, that has a zero book value in the owner's (EDF) accounts and a negative market value (the Dutch AREVA client utility had to pay EDF in order to get rid of its plutonium). The plutonium economy has turned out representing a very expensive, environmentally polluting strategy that constitutes a major proliferation risk. (For details on the French plutonium program, see Mycle Schneider, Yves Marignac, "Reprocessing of Spent Nuclear Fuel in France", IPFM, Princeton University, April 2008, http://www.ipfmlibrary.org/rr04.pdf)

[31] The use of direct resistance electric space heating is an energetic absurdity. Between two thirds and three quarters of the primary energy is lost in the transformation into electricity and its distribution. Therefore electric space heating leads to up to three times higher greenhouse gas emissions than for example natural gas based central heating. Electric heating is also the number one origin of energy poverty in France. (For details see Mycle Schneider, "Nuclear Power in France – Beyond the Myth", commissioned by the Greens-EFA Group in the European Parliament, Brussels, December 2008, http://www.greens-efa.org/cms/topics/rubrik/6/6659.energy@en.htm

Historical French nuclear assistance, know-how and hardware transfer

> *The French love to sign agreements. It's a mania of the Foreign Affairs Ministry, which by and by has gone through all other ministries. A minister arrives for a visit in a foreign capital and he wants to sign an agreement. Not me.*
>
> Pierre Guillaumat
> Minister of Defense under President De Gaulle,
> former General Administrator of the French Atomic Energy Commission[32]

On 15 January 2008 France signed a nuclear cooperation agreement with the United Arab Emirates (UAE). In December 2006 Gulf Cooperation Council (GCC) members Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the UAE had decided to develop a joint nuclear technology program for peaceful uses. France and the UAE also signed an agreement, the same day as the nuclear deal, for France to set up a military base in the UAE.

The UAE nuclear cooperation agreement was only one in a series of deals signed by France in the region over the past two years. Other partner countries included Algeria, Libya, Morocco, Qatar and Tunisia. In March 2008, Michelle Smith and Charles D. Ferguson, analysts with the US Council on Foreign Relations commented in the *International Herald Tribune*:

> The recent war games in the Gulf with France, Qatar and the United Arab Emirates are connected to French President Nicolas Sarkozy's nuclear diplomacy. Sarkozy has been leveraging France's leading civilian nuclear technology to gain diplomatic, commercial and military advantages with countries in the Middle East, as well parts of Africa and Asia.[33]

This describes what France has been doing over the last six decades, generously offering nuclear technology in order to increase its geopolitical influence in various regions of the world – beginning in the Middle East.

In the 1950s France signed nuclear cooperation agreements with several countries, including Canada, India, Israel, Sweden, Switzerland, the US and Yugoslavia. In the 1960s Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Chile, Germany, Indonesia, Iran, Italy, Japan, Pakistan, South Vietnam, the Soviet Union, Spain, Tunisia and Uruguay were added. In the 1970s agreements were signed with even more countries, including Bangladesh, China, Libya, Mexico, Philippines, Portugal, Qatar, Saudi Arabia and South Korea.

Many of these agreements never resulted in nuclear power programs. Of the 34 countries that signed nuclear cooperation agreements in these three decades 15 never started a power reactor, one phased out nuclear power (Italy), one has developed nuclear weapons but no power reactor (Israel) and one is in the course of building a power reactor but not with French help (Iran). In respect of the latest round of agreements signed by France in the Middle East, whether nuclear plants will actually be built in those countries is secondary to France's broader political and strategic purposes. In fact, considering the small size of these countries' electricity grid systems and the total absence of a regulatory framework and nuclear infrastructure, the realization of most, if not all of the nuclear projects is highly unlikely, especially as they are all also blessed with huge amounts of collectable solar energy.

Many of the early French partner countries were at some point involved in nuclear weapons-related research, including "unsuspicious" countries like Switzerland and Sweden. The Swiss studied the possibility of a nuclear weapons program until they signed the NPT in 1969 and possibly even later. Sweden studied nuclear weapons from the 1950s onwards, later importing weapons grade plutonium from France and Britain and carrying out a series of sub-critical implosion experiments as late as 1971 and 1972.[34] A recent paper on sensitive nuclear exports[35] lists French transfers to Egypt (hot cells for

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[32] Interview with the author and Georg Blume, Paris, 10 September 1986, published as "Interview avec Pierre Guillaumat, le constructeur de la bombe française", Damocles, Lyon, 4th Trimester 1995
[33] International Herald Tribune, "France's Nuclear Diplomacy", 11 March 2008
[34] PBS, "Tracking Nuclear Proliferation – Sweden", 2 May 2005
http://www.pbs.org/newshour/indepth_coverage/military/proliferation/countries/sweden.html
[35] Matthew Krönig, "Exporting the Bomb: Why States Provide Sensitive Nuclear Assistance", American Political Science Review, Vol. 103, No. 1, February 2009

reprocessing, 1980-1982), Israel (reprocessing plant, 1956-1965), Japan (pilot-scale reprocessing plant, 1971-1974), Pakistan (reprocessing plants, 1974-1982), South-Korea (reprocessing plant components 1974-1975), Taiwan (reprocessing plant components, 1975).

In many cases France has been a significant provider of know-how, materials and even manpower to foreign nuclear power and nuclear weapons programs. Louis Armand, key nuclear strategist in the 1950s, French negotiator of the Euratom Treaty, member of the *Corps des Mines* and President of the Industrial Equipment Committee at the CEA, clearly defined the political advantages of exporting nuclear technology, including to developing countries. In November 1956 he told the French Parliament that

> Currently, the biggest influence that a technically developed country can have over an underdeveloped country stems from the supply by the first of machines to the second for its basic development. Now, the underdeveloped countries are all countries that do not have energy or that have not figured out how to use their energy; consequently, to offer it new energy is to give more than technology, it is giving it hope.
>
> This is why the export of atomic energy generating materials constitutes a political gesture. If France wants to follow that new policy of technical assistance, it must know how to produce machines that are not inferior to those of the giants.[36]

The current policy of President Nicholas Sarkozy in promoting French civil nuclear industry abroad is fully consistent with the orientation first adopted by France over 50 years ago, and practiced ever since.

Matthew Krönig's contemporary paper on *sensitive* nuclear exports[37] lists French nuclear transfers to Egypt (hot cells for reprocessing, 1980-1982), Israel (reprocessing plant, 1956-1965), Japan (pilot-scale reprocessing plant, 1971-1974), Pakistan (reprocessing plants, 1974-1982), South-Korea (reprocessing plant components 1974-1975), Taiwan (reprocessing plant components, 1975).

The following here are a few short country case studies of French foreign nuclear cooperation.

Israel

In 1949 the French nuclear physicist Francis Perrin, who played a key role for the development of the French nuclear weapons program, invited Israeli scientists (barely two years after the foundation of the State of Israel) to study at the newly created CEA nuclear research site at Saclay. Both countries developed a close nuclear cooperation that was not only a one-way assistance. Israeli scientists reportedly assisted France in the construction of the first plutonium production reactor and the UP-1 reprocessing plant at the Marcoule site. France apparently also profited from two Israeli patents on heavy water production and low-grade uranium enrichment.[38] Some analysts consider that: "The cooperation was so close that Israel worked with France on the preproduction design of early Mirage jet aircraft, designed to be capable of delivering nuclear bombs."[39]

France signed the first nuclear agreement with Israel in 1954, which covered the uranium extraction from phosphates and the production of heavy water. In 1956 an agreement was signed between the CEA and the Israeli Atomic Energy Commission for the sale of a large research reactor. Hundreds of French technicians and engineers assisted in the building of the Dimona reactor and the underground reprocessing plant in the Negev desert. It is further asserted that the cooperation with the French made Israeli nuclear testing unnecessary. Israeli experts were invited to the first French nuclear tests, had access to test explosion data and received separated plutonium.[40]

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[36] Louis Armand, Assemblée Nationale, 5 July 1956

[37] Matthew Krönig, "Exporting the Bomb: Why States Provide Sensitive Nuclear Assistance", American Political Science Review, Vol. 103, No. 1, February 2009

[38] Warner D. Farr, "The Third Temple's Holy of Holies: Israel's Nuclear Weapons", The Counterproliferation Papers, USAF Counterproliferation Center, Air War College, Air University, Alabama, September 1999

[39] Stephen Green, "Taking Sides. America's Secret Relations with a Militant Israel",William Morrow and Company, New York, 1984, cited in Warner D. Farr, op.cit.

[40] Warner D. Farr, op.cit.

The French assistance to Israel was initiated and carried through by the CEA under the responsibility of its General Administrator Pierre Guillaumat, godfather of the *Corps des Mines*. Guillaumat was also the man behind the French bomb program. It is quite clear that some aspects of the two weapons programs were implemented at the level of the two Atomic Energy Commissions, without even knowledge of the French ministers.

The build-up of the Israeli nuclear weapon program has profoundly modified the geopolitical situation in the Middle East. The French interest was then primarily to create a counter-weight to Egypt that had considerably increased its military capabilities with assistance from Eastern block countries.

Iraq

Negotiations about the delivery of a large research reactor from France to Iraq started in 1974 and were concluded in 1975 with the signature of a nuclear cooperation agreement. The goal was to obtain far-reaching assistance in the construction of a large material testing reactor, called Osirak or Tammuz-1, based on the French Osiris reactor that was operating with high-enriched uranium fuel. While the goal probably was to generate plutonium in blanket material around the uranium core, the high-enriched uranium is also directly weapons usable. There was hardly any ambiguity over the intentions of Iraq's leader. As the *Nuclear Weapon Archive* puts it:

> For his part, Saddam Hussein did not pussy-foot around about his intentions. Just before flying to France to close the Osirak deal in September 1975, he gave an interview to a leading Arabic language newsmagazine from Beirut in which he declared that his country was engaged in "the first Arab attempt at nuclear arming.[41]

As in the case of the nuclear cooperation with Israel, the CEA played a key role in the implementation of the agreement with Iraq. Between 1970 and 1978 the CEA was dominated by the remarkable strategist General Administrator André Giraud[42] and his number two Michel Pecqueur[43]. The 70 MW model reactor Osiris was designed, built and operated by the CEA in Saclay since 1966. Until 1980 it was operated with weapons grade uranium (93%). While there was opposition inside the French scientific community against the delivery of a significant quantity of weapons grade uranium (more than one bomb worth) to Iraq and requests for the redesign of low enriched fuel for Osiris, Iraq insisted on the design and obtained the delivery of HEU fuel.

In 1981 Israel bombed and destroyed the Osirak reactor, by then in an advanced state of construction. France knew about the bombing upfront. It is rumored that Simon Peres, the mastermind of the Israeli nuclear program, had informed his friend François Mitterrand about the date of the operation, originally planned for 10 May 1981, the day Mitterrand should get elected president.

Iraq had also acquired key equipment for laboratory work on uranium enrichment like distillation units, mixer-settler batteries, pulsed columns and pumps for its laboratory-scale work from France, Sweden and Germany. Iraq attempted to copy the French Chemical enrichment process CHEMEX. After the invasion of Kuwait, the Iraqi government launched a crash program in order to extract from fresh fuel and divert 39.5 kg of uranium enriched to about 84%, most of which was delivered by France.[44]

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[41] Nuclear Weapon Archive, "Iraq's Nuclear Weapons Program - From Aflaq to Tammuz", 27 December 2001, http://nuclearweaponarchive.org/Iraq/IraqAtoZ.html

[42] André Giraud was one of the godfathers of the *Corps des Mines*. He strongly influenced France's nuclear strategy at home and abroad throughout the 1970s and early 1980s.

[43] Michel Pecqueur was also engineer of the *Corps des Mines*. He succeeded André Giraud at the head of the CEA in 1978 until 1983.

[44] David Albright, "Iraq's Programs to Make Highly Enriched Uranium and Plutonium for Nuclear Weapons Prior to the Gulf War", ISIS, 1997, revised October 2002

Photo: The Weekly Standard

Note: On 6 September 1976 French Prime Minister Jacques Chirac invites Iraq's Saddam Hussein to visit the CEA nuclear research center in Cadarache.

India

India was one of the earliest partners in the French foreign nuclear cooperation. In 1951 the two countries signed an agreement covering the study of beryllium. In 1965 a full-scale cooperation agreement on the Uses of Atomic Energy for Peaceful Purposes was signed. Further specific agreements were signed in 1969 (for a heavy water production plant, and the Kalpakkam fast breeder reactor) and in 1971 (global breeder cooperation). Fast breeder reactors are particularly proliferating since they generate weapons grade plutonium as a by-product in the so-called blanket.[45]

Even after India had diverted know-how, facilities and materials from peaceful purposes and exploded a nuclear weapon in 1974, France continued to cooperate and exchanged notes on the supply of enriched uranium in 1976. In 1982 followed an agreement on the supply of fuel for the two Tarapur reactors. Reportedly, France also provided fuel for the two Rajasthan units after 1989.[46]

Oon 30 September 2008,[47] less than a month after the Nuclear Suppliers Group (NSG) exempted India from its basic rule, (adopted in 1992) restricting nuclear exports to countries, like India and Pakistan, that refuse IAEA safeguards on their entire nuclear activities (Full Scope Safeguards), France and India signed a comprehensive - but confidential - nuclear cooperation agreement. Unlike in the U.S. the French Parliament did not have to be, and was not, consulted.

Pakistan

In 1962 Pakistan and the CEA on behalf of France signed an agreement on the Cooperation in the Field of Nuclear Energy. It is unclear what activities have been carried out under the agreement in the first 10 years. According to Abdul Qadeer Khan, now disgraced outside Pakistan, who directed Pakistan's nuclear weapons program, the decision to engage the country in the process to build the bomb was taken in 1973-1974. However, other sources put the date as early as January 1972.[48] In 1973-74 the French company SGN, that helped build both the Dimona reactor in Israel and the French and Israeli reprocessing plants, negotiated the design and construction of a large spent fuel reprocessing plant. A contract was signed between SGN and the Pakistan Atomic Energy Commission (PAEC) on 18 October 1974. In 1976, France and Pakistan signed the highly controversial agreement on the construction of the 100 MT facility that could have separated between 100 kg and 200 kg of plutonium per year (a warhead or bomb can be built with a few kilograms, depending on its quality). The project was terminated in 1978 following massive pressure by the U.S. administration under President Carter. However, the advancement of the project most likely had already included the

[45] Breeder blanket elements are made from depleted uranium (essentially U238). Plutonium-239 is formed by neutron capture.
[46] Leonard Spector, "Nuclear Ambitions", Carnegie Endowment, 1990
[47] The French signed the agreement even one day before the U.S.-India deal passed Congress.
[48] Pakistan Military Consortium, http://www.pakdef.info/nuclear&missile/timeline2.html

transmission of blueprints[49] that helped Pakistan, probably with some Chinese assistance, to acquire an operational reprocessing capacity.

After the interruption of the official French assistance, Pakistan set up a complex network of suppliers that continued the supply of materials necessary for the bomb project. The supply system was organized via the Pakistan embassy in Paris.[50] A number of French companies (including Leybold Heraeus Sogev) were involved in the mostly illegal trafficking and Air France delivered the material to Pakistan. Libya co-financed the nuclear shopping with at least 100 million dollars and traded in the training of 18 Libyan experts. The listings of money transfers discovered by German prosecutors don't name any companies as clients except the Technology and Science Section of the Pakistan embassy in Paris. The French company Pechiney[51] delivered high quality zirconium and zircaloy tubes to Pakistan until 1988, although doubts had come up at the Ministry of Foreign Affairs about the final destination of the material as early as 1985. In November 1987 the UK representative of the non-proliferation group of the European Political Cooperation (EPC), then the EU's foreign policy arm told his colleagues that Pakistan would already possess a number of "small nuclear weapons".

South Africa

In 1964 France and South Africa signed an agreement on the long-term supply of natural uranium. In 1976 the two countries agreed on the construction of the two 900 MW commercial light water reactors in Koeberg. Construction started the same year. The French government and the nuclear builder Framatome did not see any problems to deal with the apartheid regime. Framatome's official story writing says: "Lady Luck smiled at the company: the consortium that was in the first place, headed by General Electric, soon ran into insurmountable political difficulties. So Framatome was called to the negotiating table, and finally won the contract."[52] The Koeberg construction site was bomb attacked by the ANC in 1982 and the control rod mechanisms were destroyed. The start-up was delayed, but less than anticipated, because EDF gave up components originally destined for another project. Numerous nuclear experts were trained in France until the start-up of the two Koeberg units in 1984 and 1985.

In addition to the reactor project in 1996 France and South Africa agreed to cooperate on molecular laser isotope separation, a precursor to separating out the most fissile isotopes.

France's Role in the World Nuclear Industry

France has installed nuclear departments in its embassies in China, Japan, Russia, South Korea and the U.S.. "Nuclear counselors", representatives of the CEA that report directly to the ambassador, also exist in French embassies in Finland, Germany, Hungary, India, U.K.[53] and at the Permanent French Representations at the EU in Brussels and at the IAEA in Vienna.[5455] Their task is to watch scientific and technological developments, and especially "support cooperation programs between CEA and other French organizations and industrialists with their counterparts in the nuclear and non nuclear fields".[56]

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[49] The Pakistan Military Consortium claims: "All the blue prints of design of the plant are handed over by SGN to PAEC prior to the cancellation of the agreement." see http://www.pakdef.info/nuclear&missile/timeline2.html

[50] for details see, Mycle Schneider, "Nucléaire: Paris, plaque tournante du traffic pakistanais", Politis, Paris, 22-28 February 1990; an English language summary has been published by the Center for Nonproliferation Studies (CNS) as Document N°4558 in "Pakistan's Nuclear Related Facilities", The Nonproliferation Review, Volume 4, Number 3, April 1997

[51] Georges Besse, Corps des Mines, was CEO between 1982 and 1985

[52] Framatome, "Framatome – An Industrial and Business Success Story", 1995

[53] Strategic positions, like currently the one of the UK Nuclear Counselor for future planned investments, can be occupied by a member of the *Corps des Mines*.

[54] CEA, CEA News, January 2008

[55] In comparison, while the US Embassies in France and in the UK do have a Counselor or a Department for Scientific, Technological and Environment Affairs, they do not have a dedicated nuclear counselor. Respective Canadian Embassies in France and the UK do not have dedicated science and technology officials, leave alone nuclear counselors.

[56] CEA, Bilateral Agreements, web, consulted 17 January 2009 http://www.cea.fr/english_portal/cea/international_cooperation/3_bilateral_agreements

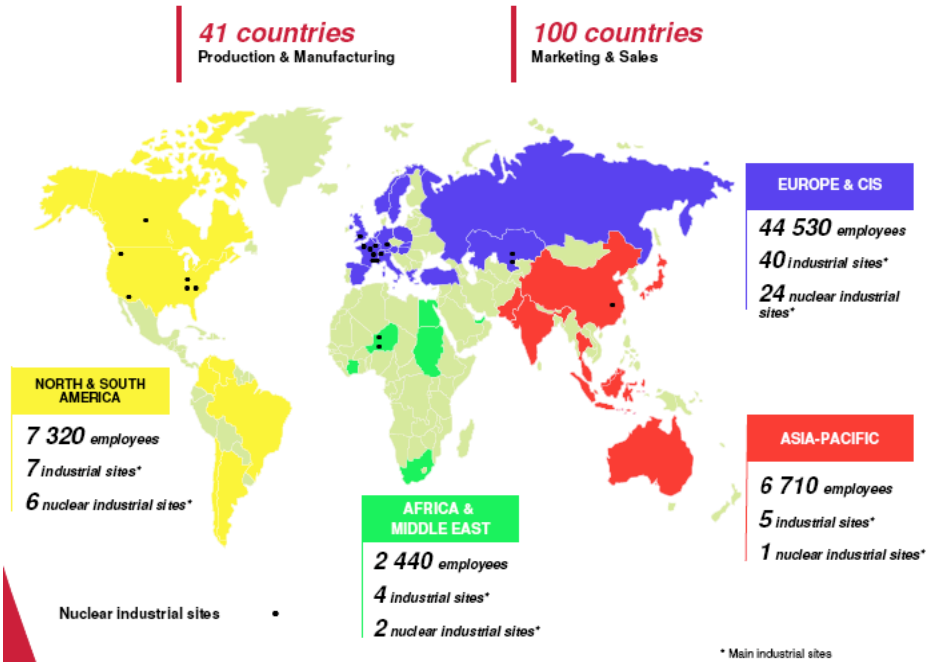
Today AREVA Group is the central industrial French actor for the entire nuclear fuel chain. AREVA Group was formed in 2001 under the leadership of Anne Lauvergeon, on the basis of the legal structure of CEA-Industrie with the CEA holding 78.96% of the shares, other shareholders of Framatome[57] (now AREVA NP) 9%, other shareholders of COGEMA[58] (now AREVA NC) 8% and Investment Certificates 4%. The objective of AREVA's establishment was:

> • to create an industrial group with a world leadership position in its businesses and to streamline its organization, giving the group:
>
> • complete coverage of every aspect of the nuclear business and a unified strategy with respect to major customers;
>
> • an expanded customer base for all of the group's nuclear products and services (…).[59]

The main nuclear sectors are uranium mining, conversion, enrichment, fuel fabrication, nuclear island fabrication, maintenance, spent fuel shipment and storage, reprocessing, decommissioning and waste management. AREVA is certainly right to claim the status "N°1 worldwide in the entire nuclear cycle".[60] The group employs over 65,000 people, has manufacturing facilities in 43 countries, and a sales network in more than one hundred. Consolidated sales revenues reached almost €12billion in 2007. The geographical distribution of sales revenues was Europe and CIS 56%, Asia-Pacific 19%, North and South America 17% and Africa and Middle East 8%. The income distribution amongst the three nuclear divisions, that represent 64% of AREVA's total revenues, was Front End (uranium exploration, mining, conversion and enrichment, nuclear fuel design and fabrication) 26%, Reactors and Services Division (design, construction, maintenance) 23% and Back End ("treatment and recycling of fuel", logistics, engineering, clean-up).[61]

AREVA's world market share in the front-end activities (see figure 3) are respectively 20-25% in uranium mining, 25-30% in uranium conversion, 20-25% in uranium enrichment and 30-35% in low enriched uranium fuel fabrication. AREVA's main international competitor in this area is the Russian AEP with similar shares.

Figure 2: AREVA Representation of its "Global Infrastructure"



Source: AREVA, Whittal presentation, February 2008

[57] French State; EDF, Framépargne (Framatome employees)
[58] Total, Caisse des Dépôts et Consignations (CDC), Erap
[59] AREVA, "Reference Document 2007", 15 April 2008
[60] AREVA, "AREVA at a glance", March 2008
[61] AREVA, "Reference Document 2007", 15 April 2008

In reactor building and servicing the market share is 20-25% while AREVA is entirely dominating the backend activities spent nuclear fuel reprocessing and uranium-plutonium mixed oxide fuel (MOX) fabrication with respective market shares of 70-75% and 65-70%. However, it should be noted that France is the only country left besides the UK that still operates large-scale commercial plutonium facilities. By the end of 2008, practically all of the foreign spent fuel had been processed, with the operator of the La Hague reprocessing plant, AREVA NC (former COGEMA) basically left with its domestic reprocessing client.[62]

The EURODIF Case

The international consortium EURODIF that operates the Pierrelatte (Tricastin) uranium enrichment plant is a significant player on the international enrichment scene. EURODIF supplies enriched uranium to about 30 utilities or about 100 reactors, mainly in Europe, Asia and in the U.S..

The history of the consortium is a typical example of the "French way". Georges Besse[63], member of the *Corps des Mines*, started up EURODIF in 1973 as a consortium amongst five countries, France, Belgium, Italy, Spain and Sweden.[64] The CEA held the French majority shares. It was clearly an initiative to break the enrichment monopoly of the U.S.. The logic was prolonged in 1976 with the creation of COGEMA as a 100% subsidiary of the CEA under private law.

Very early Iran was integrated into the small community of uranium enriching countries. On 23 February 1974, even before the signature of the safeguards agreement between Iran and the IAEA, France signed an agreement with Iran that created the company SOFIDIF[65]. Iran put up over US$1 billion and in 1975 took over via SOFIDIF the Swedish 10% share in EURODIF and was in turn to receive 10% of the produced enriched uranium. The EURODIF enrichment plant started up in 1979 but the latter part of the Iran deal was never honored and the conflict went on for ten years until the International Chamber of Commerce in January 1991 awarded Iran the equivalent of €143 million as part of the settlement, to be added to some €500 million that had already been paid. A final settlement agreement, whose details have remained secret, was signed between France and Iran in October 1991. France is said to have agreed to pay another $1 billion. However, it remains uncertain whether this includes part of the payments carried through before.[66]

SOFIDIF still exists, still holds the same share in EURODIF and is still active. In a letter dated 13 February 2006 addressed to the CEO of SOFIDIF, Reza Aghazadeh, Vice-President of Iran and President of the Iranian Atomic Energy Organisation, informs its recipient about the replacement of the Iranian representatives on the board of SOFIDIF. As recalled during SOFIDIF's General Assembly on 16 June 2006, the purpose of the company is "to participate in the study, the realisation and the operation of uranium enrichment plants based on the French gaseous diffusion technique".[67] The operation is good business for the EURODIF shareholders. In 2005 SOFIDIF reached a net profit of €17.7 million and decided to pay out €17.6 million in dividends. This corresponds to € 12.80 per share – on steady increase and twice as much as 2002 – which is excellent return on investment, considering the share value of €15.25 each. The Iranian Atomic Energy Organisation had a net income from dividends in 2005 of €7 million from uranium enrichment in France. Currently, Iran cannot

[62] see Mycle Schneider, Yves Marignac, op.cit.
[63] Georges Besse became first CEO of EURODIF and in 1978 CEO of COGEMA. He was assassinated on 17 November 1986 by the French terrorist group "Action Directe". The current enrichment facility has been renamed "George Besse Plant". A replacement facility George Besse II is in the planning stage.
[64] The current EURODIF shareholders are: AREVA NC: (44.65%); Sofidif, France/Iran: (25%), Synatom, Belgium: (11.11%), Enusa, Spain: (11.11%); Enea, Italy (8.13%). AREVA owns in total directly and indirectly a majority of 59.65% of the shares.
[65] 60% French Atomic Energy Commission, later COGEMA and today AREVA NC, 40% Iranian Atomic Energy Organisation (OEIA)
[66] Several murders and terrorist attacks were apparently linked to the EURODIF affair. For a good summary of the EURODIF history see http://www.techno-science.net/?onglet=glossaire&definition=3530
[67] Rapport de gestion à l'Assemblée Générale Ordinaire concernant l'exercice clos le 31 décembre 2005

access those revenues, which remain frozen in French banks as a consequence of the conflict over its own enrichment activities.[68]

The apparent contradiction between Iran's involvement in the EURODIF uranium enrichment consortium and international concerns about Iran's enrichment activities at home will likely only be overcome when the EURODIF plant shuts down a few years from now.[69]

In the meantime, EURODIF is facing a commercial backlash in the U.S.. In 2001 the U.S. Department of Commerce brought a case against EURODIF to prevent the consortium from practicing dumping prices on the U.S. market. In January 2009 the U.S. Supreme Court overruled an earlier judgement by the Federal Court and confirmed the opinion of the Department of Commerce to consider the enriched uranium to a good rather than to a service exempt from U.S. anti-dumping legislation. It is unclear at this point what commercial consequences the ruling will have on EURODIF sales of enriched uranium on the U.S. market.

French share holding in foreign nuclear companies and international activities (by sector)

French post-war efforts to jump-start a nuclear program were severely hampered by restrictions to access then known uranium resources that were "monopolized by the Anglo-Saxon powers" and influenced the choice of a heavy water based natural uranium reactor for the first experimental unit (ZOE) that started in France in 1948.[70] The discovery of a uranium deposit in France (Limousin) around the same time and the discovery by the French Overseas Mining Bureau of uranium in Niger in 1957 gave France access to significant resources it could use freely for civil and military purposes. Although France was by then a member of EURATOM, under EURATOM rules it only had to declare uranium stocks open to safeguards or not; there is no prohibition under EURATOM for the two nuclear weapons countries against military uses of uranium. Eventual restrictions on end-use are requested by the exporting country, which was not the case for Niger.

Especially since the 1970s and the creation of COGEMA (now AREVA NC) in 1976, the French nuclear industry has increasingly attempted to invest in foreign companies and industrial activities. The last few years have seen an unprecedented wave of new international Joint Ventures (JV), cross participations and takeovers (see Annex 2 for an AREVA company chart). AREVA has attained an unrivaled leading position in the international market. Its annual turnover in the nuclear business is more than twice as high as the number two, the Russian integrated nuclear group AtomProm created in 2007 (see figure 4).

[68] Iran's Ambassador in France Ali Ahani, confirmed that the dividends are blocked in reply to a question by the author during the International Conference "Gouvernance Internationale du Nucléaire", 12 February 2008

[69] Former French Ambassador François Scheer, now special advisor to AREVA's CEO, has stated that this is how the "problem" would be solved (in reply to a question by the author during the International Conference "Gouvernance Internationale du Nucléaire", 12 February 2008)

[70] Bertrand Goldschmidt, "Le Complexe Atomique – Histoire politique de l'énergie nucléaire", 1980, p. 137

Figure 3: AREVA's Relative Market Shares in the World Nuclear Market

		Market 2007	CAMECO	URENCO	USEC	AREVA	Toshiba / Westinghouse	NDA/BNFL[2]	ARP (Russia)[3]	General Electric / Hitachi[4]	Others
Front End	Mining/Natural uranium*	65,000 MT	15-20%		5-10%[1]	20-25%			20-25%		25-30%
	Conversion/Chemistry	60,000 MT	20-25%		5-10%[1]	25-30%			25-30%		20-25%
	Enrichment*	45 million SWU**		20-25%	25-30%	20-25%			20-25%		5-10%
	Natural uranium fuel (UO_2)	6,800 MT				30-35%[9]	20-25%		10-15%	15-20%	10-15% (MHI)
	Reactors and Services	€15 billion				20-25%	15-20%		5-10%	10-15%	35-40%
Back End	Treatment***	31,150 MT				70-75%		10-15%[5]	10-15%		JNFL[6] in future
	Recycling (MOX fuel)***	2,260 MT				65-70%		1-5%[7]			25-30 %[8] (Belgonucléaire) JNFL[6] in future)

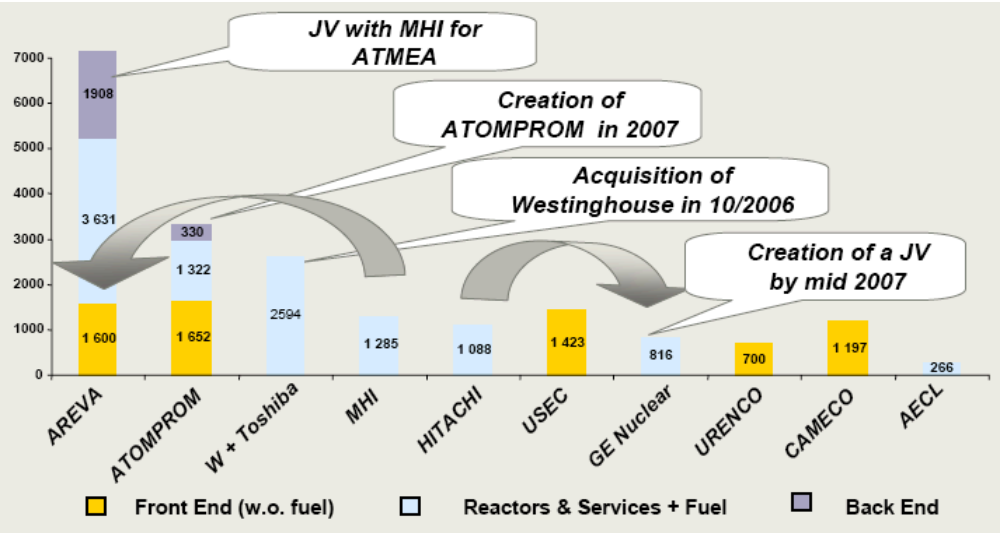
* Compared to 2006, the lowering of tails assay linked to rising uranium prices reduced the uranium market and increased the enrichment market.
** Separative work units.
*** Cumulative amount, in metric tons of heavy metal, of used fuel treated and of MOX fuel fabricated, according to AREVA estimates.
(1) Usec sells natural uranium and conversion services connected with its enrichment operations or its business with the US Department of Energy, but does not have its own mining or conversion operations.
(2) The Management and Operation contract for the Sellafield site is being rebid by the NDA, which should award a contract by the end of the first half of 2008. Under a 10-year agreement signed in 2005, Cameco purchases conversion services from BNFL. These services appear either in the Cameco column or in the "other" column.
(3) AtomEnergoProm.
(4) The final decision to merge their nuclear operations was made on July 12, 2007.
(5) In April 2005, the NDA's Thorp treatment plant at Sellafield was shut down following the detection of a leak in process piping in one of the plant's shielded cells known as the "clarification cell". The British health and safety regulator agreed to the plant's restart on January 10, 2007.
(6) JNFL's treatment plant (800 MT) and MOX fabrication plant (130 MT) are expected to start up in 2008 and 2012 respectively.
(7) Ramp-up of the NDA's SMP plant is currently in progress.
(8) Belgonucléaire's Dessel plant ceased production in mid 2006.
(9) Including the Yi Bin fuel fabrication plant, just as Westinghouse's market share includes Enusa data.

Source: AREVA, Reference Document 2007, 2008

Note: The "Natural Uranium Fuel (UO2)" line covers low enriched rather than natural uranium fuel.

Figure 4: AREVA's Leader Position: Average 2005-2006 Revenues of Key Nuclear Suppliers
(in million euro)

M€



Source: AREVA, Poncelet, "Nuclear Renaissance: What is at stake for Europe?", 14 November 2007

Uranium Mining[71]

AREVA owns shares in uranium mines in Canada, Kazakhstan and Niger. In 2007 AREVA took control over the Canadian uranium company Uramin and now holds 100% of its shares. With the acquisition of Uramin, the group now has sites in Namibia, South Africa and the Central African Republic, which should lead to the production of more than 7,000 MT per year beginning in 2012. AREVA also plans to start production at two large deposits at Cigar Lake in Canada and the Imouraren site in Niger.

Figure 5: Top 10 Uranium Producers in the World 2007

Rank	Producer	Production	%
1	Cameco	7,616	18%
2	Rio Tinto	7,172	17%
3	AREVA	6,046	14%
4	Kazatomprom	4,956	12%
5	AEP/TVEL	3,627	9%
6	BHP-Bill/ODM	3,388	8%
7	Navoi / Uzbekistan	2,300	5%
8	Vostgok / Ukraine	1,000	2%
9	CNNC / China	950	2%
10	Nufcor / South Africa	750	2%
	Total Top 10	**37,805**	**91%**
	Other	3,895	9%
	World production	**41,700**	**100%**

Source: AREVA.

Uranium Mining in Canada

All of the uranium mining operations that are carried out under participation by AREVA are located in Northern Saskatchewan and operated by AREVA Resources Canada Inc.

AREVA operates the McClean Lake mine and is a 70% owner alongside Denison Mines Ltd, which has a 22.5% stake, and Overseas Uranium Resources Development Company Ltd of Japan (OURD), which owns 7.5%. Uranium production started in 1999. The ore is processed in the Jeb mill, commissioned less than ten years ago. The mill's capacity of about 3,000 MT is to increase by 2009.

AREVA holds 30.2% in the McArthur River mine, which is operated by Cameco Corporation, which holds a 69.8% interest. McArthur is the largest high-grade uranium deposit in the world. The deposit was discovered in 1988 and mining began in December 1999. The ore is processed at the Key Lake mill, which is operated by Cameco Corporation (83.3% of the capital, AREVA 16.7%). In 2003 the mine was partially flooded.

The Cigar Lake deposit, located 450 m below the surface, was discovered by AREVA in 1981. It will be operated by a joint venture consisting of Cameco Corporation (50.03%), AREVA (37.1%), Idemitsu Uranium, Exploration Canada Ltd (7.88%) and TEPCO Resources Inc.(5%). Cigar Lake is the world's second largest high-grade uranium deposit, after McArthur River.

According to AREVA, "on October 23, 2006, the side drift in the upper level of the mine partially collapsed just below the water table, completely flooding the mine. (…) At this stage, Cameco believes that operations could restart in the coming years, subject to approval by the Canadian Nuclear

[71] Information mainly based on AREVA, "Reference Document 2007", 15 April 2008, unless otherwise noted.

Safety Commission (CNSC). "72 Cigar Lake should produce 6,900 MT of uranium per year at full capacity (18 million pounds of U3O8).

AREVA owns 69.16% of the Midwest mine project joint venture and is the designated future operator. Denison Mines own 25.17% of the project and Overseas Uranium Resources Development Company Ltd of Japan (OURD) 5.67%. Anticipated annual production is approximately 3,000 MT of uranium. The ore will be processed by the Jeb mill. However, due to the economic situation, the development of the project was postponed in late 2008.

Uranium Mining in Niger

The French Overseas Mining Bureau discovered uranium in Niger in the late 1950s. The uranium deposit is located in the piedmont plains. Two companies, Somaïr and Cominak, were established to operate the mines. Until now, only uranium deposits have only been mined in the Arlit region. AREVA's concession covers 360 square kilometers (140 square miles) and the group is planning a major exploration program and submitted 19 new permit applications in 2006. Uranium mining is a significant share Niger's income and it has been strategic for French nuclear policy since the beginning, because Niger uranium, unlike Australian or Canadian uranium for example, never had any peaceful end-use conditions attached and thus France was free to use it in its nuclear weapons program. Consequently, the issue is being dealt with on the highest government levels in both countries.

(Source: AFP/Getty Images)

Photo: AREVA CEO Anne Lauvergeon and Niger's President Mamadou Tandja[73]

Somaïr (Société des Mines de l'Aïr) was established in 1968. AREVA owns 63.4% of the capital, with the government of Niger owning the remaining 36.6% through Onarem, the national mining resources agency. Somaïr has operated several mines near Arlit since 1971. The ore is processed in a 2,000 MT mill (5.2 million pounds of U3O8) at the site. Somaïr employs about 600 people.

Cominak (Compagnie Minière d'Akouta) was established in 1974 is operated by AREVA, which owns 34% of the company shares. Other shareholders are Onarem of Niger (31%), Ourd of Japan (25%), and Enusa Industrias Avanzadas S.A. of Spain (10%). Cominak has operated the two main deposits of Akouta and Akola, near the town of Akokan, since 1978. The on-site mill has a capacity of 2,000 MT of uranium per year (5.2 million lbs of U308). Cominak employs about 1,100 people.

In July 2006, AREVA received an exploration permit for **Imouraren**, 80 kilometers south of Arlit. The permit includes an ore body, originally discovered in 1969, that AREVA has decided to restart now that market conditions are more favorable. One hundred people are currently employed at the site. In January 2009 AREVA and the Niger government signed a convention that grants AREVA to exploit the Imaouraren deposit. AREVA will hold 66.65% in a joint company that will produce about

[72] AREVA, "Reference Document 2007", 15 April 2008

[73] On 19 December 2008 in Niamey, Niger

5,000 MT of uranium per year. The initial investment is estimated to reach more than €1.2 billion and will be largest industrial project ever carried out in the country.

AREVA considers that its uranium mines are "providing jobs, the companies offer health, social and educational services to the local populations of this isolated and economically deprived area".[74] The French company stresses that "in all, AREVA is engaged in sustainable development actions in Niger planned over the next five years worth more than €6 million per year."[75] The sum corresponds to 0.5% of the estimated investment expenditure for the sole Imouraren project.

A survey carried out by French independent laboratory CRIIRAD on behalf of Niger environmental organization AGHIR IN'MAN between 2003 and 2005 identified that:

- Radioactive waste was stored closed to a public road for more than a month;
- Drinking water that exceeds WHO contamination limits;
- Contaminated metals that are available on a public market;
- Mining wastes that are stored for decades without cover.[76]

AREVA is also facing a long-standing Tuareg rebellion in Northern Niger. A Tuareg leader told AFP in January 2008: "We are going to attack the uranium mines, including those of AREVA, to stop factories functioning, prevent the exploitation of new quarries, and seize the cargo that is en route to the sea".[77] The Tuaregs demand "that parts of the profits of uranium mining are handed back to them, while Tuaregs regularly raise the issue of the ecological impact of these mining operations on the health of local populations".[78] AREVA's Vice-President for Protection of Assets and Personnel, former Navy Admiral Thierry d'Arbonneau, has been quoted as stating that the French State would do better to supply the authorities of Niger with the means to put down the rebellion of the Tuareg.[79]

The Tuaregs have illustrated in the past that they can seriously threaten AREVA's mining operations in the country. In April 2007, the Tuaregs attacked one of the mines and Dominique Pin, head of AREVA's uranium mining in Niger, admitted that “the attack caused us to stop all our operations for almost a month.”[80]

Uranium Mining in Kazakhstan

AREVA holds 51% in the mining company Katco, which was established in 1997 to develop and operate the Muyunkum and Tortkuduk deposits in southern Kazakhstan, approximately 250 kilometers north of Simkent. Shareholders include. The Kazakh company KazAtomProm holds 49% of Katco. The development of the two mines sites started in April 2004. The nominal production objective for both deposits is 1,500 MT of uranium per year (3.9 million pounds of U308). Katco produced 871 MT of uranium in 2007, about 13% of the Kazakhstan's total production. In 2008, national production increased by 28% and the country plans to increase output to some 18,000 MT by 2010, which would make the country the world's largest producer of uranium. Kazakhstan has set a uranium production target of 30,000 MT per year by 2018.[81]

Uramin’s Sites in Africa

In July 2007, AREVA took over the uranium company Uramin. Production at the Trekkopje site in Namibia is expected to begin in 2009-2010. Development has begun of the Ryst Kuil project in South Africa and the Bakouma project in the Central African Republic.

[74] AREVA, "Reference Document 2007", 15 April 2008
[75] AREVA, "AREVA and Niger, a sustainable partnership", January 2009
[76] Bruno Chareyron, "Impact de l’exploitation de l’uranium par les filiales de COGEMA-AREVA au NIGER", CRIIRAD, 20 April 2005
[77] "Tuareg rebels warn they will attack Niger's uranium industry", AFP, 30 January 2009
[78] Temoust, Press Release, 20 November 2008
[79] Le Canard Enchaîné, 5 November 2008
[80] Seeking Alpha, 20 July 2009, http://seekingalpha.com/article/41746-tuareg-rebels-threaten-uranium-mining-in-niger
[81] WNN, "Kazakh uranium output jumps in 2008", 15 January 2009

Uranium Conversion and Enrichment in Russia

Since 1966 AREVA NC has reprocessed a large quantity of spent fuel, much of it of foreign origin, at its reprocessing plant at La Hague. The foreign and some of the French reprocessed uranium, of practically no commercial value[82], has been shipped to Russia, officially for re-enrichment. However, very little of the total amount has been re-enriched. Much of it has been substituted by fresh enriched uranium.

Since 2006 there has no longer been conversion capacity[83] for reprocessed uranium in Western Europe. The only plant, operated by AREVA subsidiary Comurhex in Malvesi in the South of France, has been shut down. The entire stockpile of the reprocessed uranium to be re-enriched is therefore shipped to Seversk in Russia. Enrichment tails, the waste product from enrichment, constitutes about 90% of the material shipped to the enrichment company. In addition, if reprocessed uranium does not have any commercial value[84], tails from the enrichment of reprocessed uranium are strictly waste. In other words, Russia has turned into a large nuclear waste disposal site for Western nuclear operators.

Uranium Enrichment

In 2003 AREVA signed an agreement with the British-German-Dutch enrichment consortium URENCO to set up the Enrichment Technology Company (ETC) for research, development, design and construction of centrifuge enrichment equipment and design. A corresponding treaty between the four countries was ratified on 3 July 2006.[85]

On 30 December 2008 AREVA Enrichment Services (AES) announced that it has submitted a license application to the U.S. Nuclear Regulatory Commission (NRC) to build and operate the Eagle Rock Enrichment Facility near Idaho Falls. In September 2008 AREVA had submitted an application for a loan guarantee for the centrifuge plant to the U.S. Department of Energy.

Local promotion of the project is underway. On 14 January 2009, AREVA announced that it would take 20 high school students from local Bonneville County to France, all costs covered – "something the international company has never done before". AREVA promises a "trip to central France to an AREVA facility, then a train ride through the French countryside to the headquarters in Paris, France. And, there will be some time to take in the sights of Paris, such as the Eiffel Tower." The purpose of the so-called 'educational adventure' is "for the students and five chaperones (…) to learn about AREVA, and return to Bonneville County to educate the rest of the community." [86]

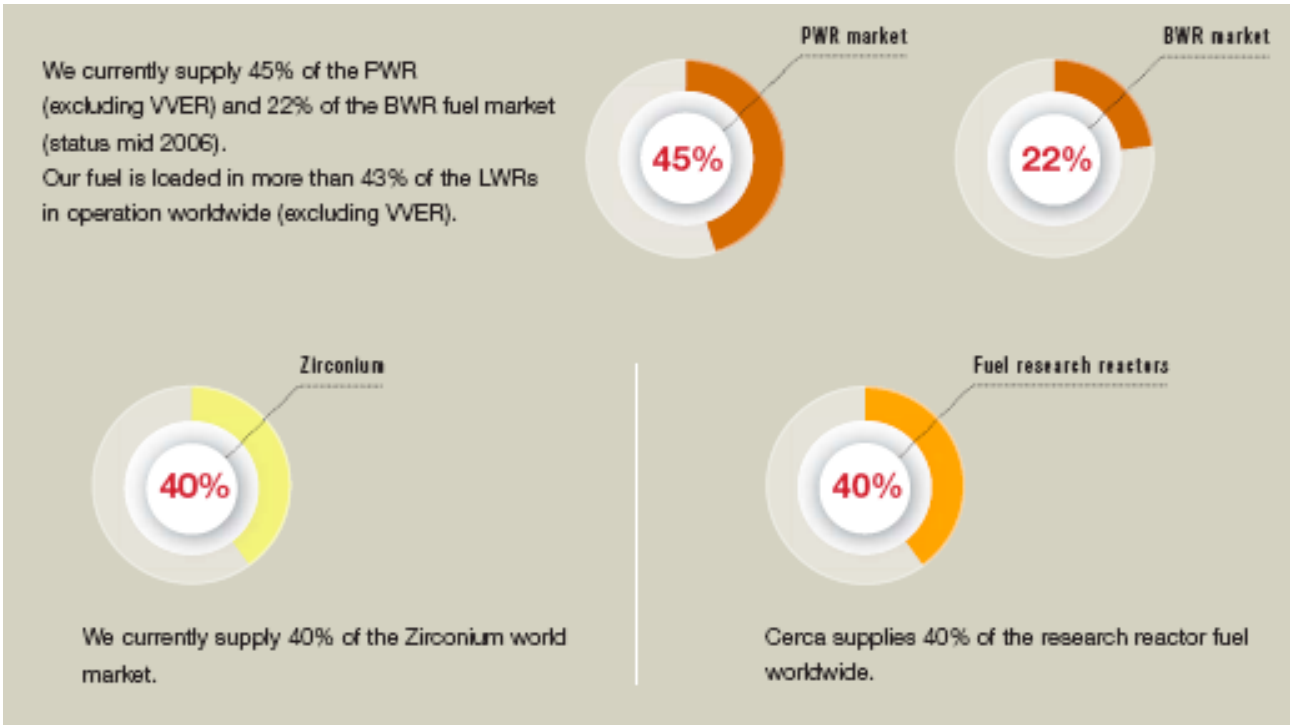
Fuel fabrication

The 100% AREVA subsidiary Advanced nuclear fuels (ANF) operates three facilities in Germany:

- A factory for cladding and structural tubes for light water reactors in Duisburg;
- A facility for spacers, upper and lower tie plates for fuel assemblies and water channels for boiling water reactors;
- Production lines for UO2 powder, pellets, fuel rods and fuel assemblies for light water reactors in Lingen.

[82] The national utility EDF has allocated a zero value to its reprocessed uranium stocks since the middle of the 1990s.
[83] The reprocessed uranium is transformed from uranyl nitrate to uranium oxide at the La Hague reprocessing plant. Prior to enrichment it has to be converted into uranium hexafluoride (UF6).
[84] Reprocessed uranium is polluted with U234 and U236, which lead to the necessity to "over-enrich" and which is inconvenient from a radiation protection point of view.
[85] AREVA, Reference Document 2007, 2008
[86] KPVI, "Students and City of Idaho Falls React to Areva's Invitation to Headquarters in France", 15 January 2009

Figure 6: AREVA Market Shares in Fuel Fabrication in 2006 (according to AREVA)



Source: AREVA, "Fuel Solutions Meeting Customer Needs", August 2007

AREVA NP also owns:

• FBFC International in Dessel, Belgium, that assembles uranium and MOX fuels for pressurized water reactors. In addition, the plant manufactures plugs and springs for fuel assemblies.

• AREVA NP Inc. operates fabrication plants for light water reactors fuel in Richland (Washington State) and Lynchburg (Virginia).

AREVA NC operates a MOX fuel fabrication facility MELOX at Marcoule in the South of France. With an annual capacity of 195 MT and the lasting technical difficulties of its only competitor (the Sellafield MOX Plant in the UK), the MELOX plant has produced 125 MT of a total of 130 MT in the world in 2007. Besides its domestic client EDF, AREVA has been supplying MOX fuel to customers in Belgium, Germany and Japan.

AREVA NC Inc. is building a MOX fabrication facility on behalf of the U.S. Department of Energy (DOE) at its Savannah River site in South Carolina. The plant is part of the national strategy to 'dispose' of excess weapons-grade plutonium by using it for commercial electricity generation in a restricted number of reactors, and then disposing of the resulting spent fuel. A priori, the facility is only to be used for excess plutonium disposition and not as part of a commercial plutonium strategy.[87] The project is several years behind schedule and significantly over budget. A recent House of Representatives Report made a number of damning statements on difficulties with the MOX project:

> The Committee is very concerned about the past and present management of the MOX fuel fabrication facility. (…) Preliminary observations by the GAO in June 2008 indicate that DOE is not following its own construction project guidance (…). Since December 2008, when the law was passed, DOE has received a notice of violation on accepting delivery of over 3,000 tons of reinforcement bar that did not meet industry standards for nuclear facilities. (…)
>
> In March 2005, the Nuclear Regulatory Commission issued a construction authorization for the MOX facility, even though concerns about the potential for an explosive reaction between chemicals used to purify plutonium oxide in the MOX

[87] Current U.S. policy remains the direct disposal of spent fuel. AREVA is lobbying hard in the U.S. in order to reverse non-reprocessing policy and gain support for GNEP, the Global Nuclear Energy Partnership, and its plutonium economy agenda.

> facility, also known as a `red oil runaway reaction,' were identified as far back as 2003 in the construction authorization review and had not been fully resolved. In 2007, NRC concluded that `significant technical questions remain unanswered.' While the NRC will not issue an operating license until these chemical safety concerns have been resolved, it is a concern of the Committee that DOE continues with the construction of the MOX facility while this design issue has not been resolved with the NRC, and that the Department is not following its own construction management guidance by proceeding with construction prior to resolving significant safety issues.[88]

These unresolved safety issues will likely lead to further delays of the construction of the plant and further cost overruns and erode the credibility of AREVA as to its capacity to build to date and budget.

AREVA is also cooperating on the construction of a MOX fuel fabrication facility with a nominal annual capacity of 130 tons at the Rokkasho-mura site in Japan, after several delays, now expected to start up in April 2012.

On 22 September 2007, AREVA and JNFL (Japan Nuclear Fuel Limited) signed an agreement to intensify cooperation on reprocessing at "their sister plants" in La Hague and Rokkasho and to make efforts jointly "to promote recycling[89] activities on the international scene" such as GNEP.[90]

Reactor Building

France exported or was a key provider for a total of eleven now operating 900 MW reactors to four countries:

- Belgium: 3 units, Tihange-1 and -2, Doel-3 (2976 MW);
- China: 2 units (1876 MW) at Lingao + 2 units (1888 MW) in a Franco British consortium at Daya Bay;
- South Africa: 2 units at Koeberg (1800 MW);
- South Korea: 2 units at Ulchin (1877 MW).

In addition, there is currently one unit under construction in Finland and another two in advanced planning stage in China.

Olkiluoto-3, Finland

The first European Pressurized Water Reactor (EPR) has been under construction in Olkiluoto, Finland since summer 2005. The Finnish utility TVO, on behalf of a consortium of about 60 large municipal and industrial consumers, signed a turn-key fixed-price contract[91] with the Franco-German consortium Framatome-ANP, now AREVA NP (66% AREVA, 34% Siemens) to supply a 1600 MW EPR. The Bavarian Landesbank – the Siemens headquarter is located in Bavaria – granted a loan of €1.95 billion, over 60% of the contract value, at a particularly preferential interest rate of 2.6%. The French public COFACE export credit agency covered an additional €720 million loan.

The construction site employs workers from some 30 countries, only about one third are Finnish workers, and 1,800 subcontractors of which 60% are foreign.

The management complexity and scarce skilled workforce turned this project turned into a nightmare for AREVA NP. As of May 2009 it was at least three years behind schedule and some €1.5 billion over budget. The construction site has encountered numerous quality-control problems, including difficulties to meet technical specifications with basic skills like base slab concreting and steel liner welds. The conflict over civil responsibility issues has led to an unprecedented conflict between the builder and commissioning entity. AREVA accused the Finnish utility in a rather blunt way stating that "TVO remained slow in communicating technical documents to the Finnish safety authority (STUK)". AREVA claims that technical document approvals, which by contract must be completed by

[88] Energy and Water Development Appropriations Bill 2009, House Report 110-921, 10 December 2008
[89] The plutonium industry uses the term "recycling" for plutonium separation and use.
[90] JNFL, Press Release 25 September 2007
[91] "The first time and certainly the last time", as a top AREVA executive stated off the record.

the client within two months, would take more than twelve months on average. AREVA concludes that "a major change in TVO's methods is required to set a definitive schedule for the project".[92]

On 5 December 2008 AREVA initiated arbitration proceedings and claims about €1 billion from the Finnish utility. TVO, which refuses to enter any arbitration procedure, most obviously defends an entirely opposite perspective of the origins of the difficulties at the construction site:

> TVO is extremely disappointed that the Consortium has not, regardless of its responsibility as turnkey supplier and its earlier promises, been able to complete the works on time or to mitigate its delays through effective acceleration measures. TVO totally rejects the Consortium's accusations that TVO has any responsibility for the delay. [93]

TVO also stresses that AREVA NP "incorrectly claims" for delays in document handling and approval, despite the fact that a "large number of the documents it is required to prepare have still not been submitted for first inspection although the plant unit should almost be complete by now", says Mr. Jarmo Tanhua, President and CEO of TVO.[94]

TVO claimed some €2.4 billion from AREVA NP for extra work and lost income from electricity sales. This does not include the consequences of the fact that Finland had integrated the operating EPR into its strategy to meet the Kyoto Protocol target. This goal is now clearly jeopardized and might have significant financial implications if Finland has to trade in carbon emissions.

In January 2009 Siemens surprised not only international observers but also its partner AREVA when it announced that it would pull out of the AREVA NP consortium and instead look for an alliance with the Russian state consortium Rosatom, which was slap in the face of the French state consortium. The Olkiluoto-3 construction disaster costs Siemens hundreds of billions of euro without having any significant influence on the decision-making. And there is no doubt that the unusual public nature of the conflict with TVO did not help to convince the German electronics giant to continue its long term cooperation with the French nuclear giant.

The Siemens move is a big blow to AREVA and not only damaging its reputation. "We are very sad", stated AREVA CEO Anne Lauvergeon. That is understandable because the cash stripped company had already to face a €2.6 gap to match the 2009 budget to which it has to add another estimated €2 billion to buy back the Siemens shares.

Taishan-1 and -2, China

Two additional EPR units are planned for Taishan, China. AREVA expects to receive the construction license in September 2009. The French company has announced the contract as a package deal of unusual dimensions. The delivery of two EPRs is to be complemented by fuel supply for a 15-year period, as well as technology transfer on spent fuel reprocessing. However, the last point seems to be somewhat controversial and it is unclear to what extent plutonium technology transfer is conditional for the entire deal[95].

In August 2008 EDF set up a joint venture with the China Guangdong Nuclear Power Holding Company (CGNPC) called Guangdong Taishan Nuclear Power Joint Venture Company Limited (TNPC). EDF holds 30% of the capital for 50 years, maximum timeframe for a joint venture in China. AREVA is supposed to deliver the nuclear island and Alsthom the turbines. The first unit is supposed to start up in 2013, the second one in 2015. EDF will provide also technical assistance and documentation. CGNPC is also the operator of the nuclear plants in Daya Bay and Lingao.

Other Reactor Projects

In the **U.S.** Constellation Energy and EDF formed UniStar Nuclear Energy LLC (50%/50%) to develop nuclear power plant projects in the country. EDF entered the capital of Constellation Energy and projects to build up to four EPRs in the U.S.. Unistar's Calvert Cliffs-3 project is "poised to be the

[92] quotations from AREVA, Press Release, 19 December 2008
[93] TVO, Press Release, 13 January 2009
[94] ibidem
[95] see Thomson Financial, "AREVA Chinese plant order conditional on waste technology deal", 15 January 2008

first new reactor built in more than 30 years in the United States. It would be one in a fleet of standardized EPRs around the country."[96] Besides Calvert Cliffs, Unistar currently has three other projects, Callaway-2 in Fulton, Missouri, Bell Bend-1, Berwick, Pennsylvania and Nine-Mile-Point-3, Oswego, New York.

On 19 February 2009, the Federal Energy Regulatory Commission voted unanimously in favor of EDF's acquisition of half of Constellation Energy's nuclear business. The acquisition still needs approval from the NRC. In September 2008, Constellation shares had plunged 58% in three days[97] as a consequence of the Lehmann Brothers debacle, and was only saved from bankruptcy by billionaire Warren Buffet who bought $1 billion worth of preferred stock prior to EDF's intervention. Nevertheless, Constellation lost $1.4 billion in the fourth quarter 2008 alone. And it became highly uncertain whether Unistar Nuclear would be able to come up with the capital requested to follow through with its nuclear plans.

On 24 February 2009 the **Italian** utility ENEL and EDF, backed by their respective governments, announced the set-up of a 50/50 consortium between the two utilities "to look into the feasibility of developing a least four nuclear reactors based on EPR technology in Italy".[98] AREVA stated in its own press release that "this brings the total number of utilities who have chosen the reactor to 10", but adds in a footnote of its own press release: "The outcome of the agreement is subject to developments in the Italian legislative and regulatory framework."[99]

Spent fuel shipment, storage and reprocessing

AREVA NC has provided commercial spent fuel shipment and reprocessing services for foreign utilities since 1966 when it opened up the first reprocessing line at the La Hague plant. The quantities of fuel and the number of clients considerably increased with the progressive start-up of light water reactor reprocessing lines in 1976 and afterwards. While no so-called low and intermediate level wastes have been returned to foreign customers, about three quarters of the high-level vitrified waste has already been shipped to foreign clients, including all of the high level waste allocated to Belgium and Japan. High-level waste shipments are still ongoing to Germany, the Netherlands and Switzerland and are planned to start to Spain and Australia in 2011 and 2015 respectively. The only additional client is Italy that started reprocessing a backlog of spent fuel in 2008 and is supposed to send back high-level waste between 2020 and 2025[100].

Shipping of compacted intermediate level waste to foreign client countries is supposed to start in 2009. Over 83% of the foreign waste packages have been allocated to Germany (57.1%) and Japan (26.3%), the rest going to Belgium, the Netherlands and Switzerland.[101]

So-called low-level wastes from the reprocessing of all spent fuel, of French and foreign origin, were dumped at the final storage site at La Hague (Centre de Stockage de la Manche, now closed) since 1969 and at the Soulaines site (Centre de Stockage de l'Aube, near Troyes, about 150 km south east of Paris) since 1992.

AREVA has also become a major supplier of transport and storage containers for spent fuel. In the U.S. AREVA is market leader with almost half of the shipment and dry storage casks provided (469 of a total of 947 at the end of 2007).

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[96] Unistar description at http://www.unistarnuclear.com/projects/cc3.htm

[97] Constellation stocks lost 77% of their value in the year prior to 18 February 2009, see Bloomberg, 19 February 2009

[98] EDF, Press Release, 24 February 2009

[99] AREVA, Press Release, 24 February 2009

[100] According to the Agreement between France and Italy signed on 24 November 2006 (Journal Officiel, 10 May 2007). It is noteworthy that the French Nuclear Safety Authorities gave a negative opinion on the agreement arguing that the technical specifications of the spent fuel do not justify such a long delay for the return of the waste. In fact, Italy did not generated any nuclear electricity after the Chernobyl accident in 1986. So the reprocessing waste would not need to cool off any more prior to shipment.

[101] AREVA NC, "Traitement des combustibles usés provenant de l'étranger dans les installations AREVA NC de La Hague – Rapport 2007", March 2008

Clean-up

Until the end of 2007 AREVA's cleanup business unit operated almost exclusively in the French market, which represented about €500 million per year. Less than 2% of its sales come from the export market. However, in November 2008 the management of the vast U.K. Nuclear Decommissioning Agency's (NDA) Sellafield site was transferred, under a commercial contract, to Nuclear Management Partners, a consortium that includes AREVA, the U.S. firm URS Washington and the U.K.'s AMEC. This huge 5-year contract with a potential prolongation to 17 years covers reprocessing operations and clean-up at the former BNFL Sellafield site. The new consortium has made sure that it won't be held liable for any potential major accidents. The government has been accused of short-circuiting an appropriate parliamentary debate on the issue. It has also been clarified that the private consortium will not be bound to the rules of the Freedom of Information Act that in the past allowed public access to a number of key documents (including the e-mail exchanges that prove the manipulation by civil servants to cut short on parliamentary involvement).[102]

Implications of Recent Nuclear Cooperation Agreements

The Sarkozy administration has negotiated multiple nuclear cooperation agreements with other nations and the president himself has traveled the world to promote French nuclear technology. “The requests by countries that wish to profit from that clean and cheap source of energy are legitimate," says French Foreign Minister Bernard Kouchner. New bilateral nuclear trade agreements have been negotiated with Algeria, Jordan, Morocco and Tunisia; major nuclear cooperation agreements were signed with China, India, Libya, South Africa and the United Arab Emirates over the last two years and, based on an agreement signed in 2002, France has pledged to assist Brazil to expand its already existing nuclear power footprint.

For the wannabe nuclear players, however, it's very unlikely that they will implement fission power programs any time soon, if ever. None of the newcomer countries have proper nuclear regulations, regulators, maintenance capacity, or the skilled workforce in place to run a nuclear plant. The head of the French Nuclear Safety Authority has estimated it would take at least 15 years to build up the necessary regulatory framework in countries that are starting from scratch.

Furthermore, their electricity grids are entirely inappropriate to handle the increased load from a 1,600 MW European Pressurized Water Reactor (EPR) built by the Franco-German nuclear power builder AREVA NP. The order of magnitude increase that a new EPR would represent of total installed generating capacity in a country like Jordan, with 1,900 MW, or Algeria and the United Arab Emirates, with roughly 6,500 MW, illustrates the absurdity of large-scale nuclear deployments in these countries. As a rule of thumb you need a permanently available reserve capacity with sufficient size to replace the largest unit on the grid. Also, the distribution system has to allow for the effective transmission of the quantities of power generated. None of these conditions are even close to being fulfilled in the Mediterranean and Gulf states.

The idea of encouraging and promoting nuclear energy seems even more surprising in countries with blatantly obvious democratic deficits and beset by armed rebel groups, many of whom have demonstrated stunning levels of menace towards their fellow citizens. Some people have labeled civil nuclear facilities pre-deployed nuclear weapons; the phrase becomes particularly significant in this context.

In the meantime, Sarkozy’s ‘announcement politics’ complements perfectly the international nuclear industry’s massive PR campaign promoting nuclear power as being back on the world's agenda. Nuclear plants are being offered by the French-state controlled AREVA, and its CEO Anne Lauvergeon - dubbed the “stylish ‘Vive les Nukes’ saleswoman” by *New York Times* writer Roger Cohen - as if they were pressure cookers offered on the local Sunday morning market. No matter whether any of these projects will ever see the light of the day, "access" to nuclear technology has become its own vaunted goal, the rest is presented as an issue of banal commercial negotiation.

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[102] Geoffrey Lean, “Officials plotted Sellafield cover-up - MPs were denied the chance to challenge sweetener to private firm's nuclear deal”, Independent on Sunday, 4 January 2009
http://www.independent.co.uk/news/uk/politics/ios-investigation-officials-plotted-sellafield-coverup-1224473.html

“We have it in France, why shouldn’t they have it in Morocco?" asks Sarkozy in a speech in Marrakech, which is as good an example of the government's stance as any other speech he has given on the issue. The rhetorical question puts Morocco on the same level as France. In doing so, the French President not only flatters his host but underlines his own authority and strategic view. "If General de Gaulle had not embarked on nuclear energy, EDF would not be today what it is… Tomorrow, I wish that Morocco chooses French civil nuclear energy."[103] The stance is also a strong reminder to the international community that France is different – especially from the United States – when it comes to its relationship with the Arab World. Logically Sarkozy tells Morocco's leaders: "France will be your partner, France makes that political choice, France will accompany you on this road." France!

As Louis Armand stated in 1956, to offer a developing country "new energy is to give more than technology, it is giving it hope" and that's one of the reasons why nuclear exports have been considered "a political gesture".[104] In fact, while the realization of a nuclear reactor sale is considered a commercial success, today the political gesture is already achieved with presenting "the offer", independently of question whether it is followed by implementation or not.

Meanwhile the Sarkozy strategy risks contributing to the steady erosion of the international non-proliferation regime that is “on the brink of collapse," as former German Foreign Minister Joschka Fischer has put it.[105] Kouchner stipulates as a “first imperative” to guarantee that the development of civilian nuclear power “never helps a country that participates in proliferation". The problem is not only that France has not always respected that "imperative" in the past, but that sensitive know-how transfer can start immediately after the signature of a binding cooperation agreement, regardless of the level of probability of the coming into being of an electricity generating plant.

The French Role in Nuclear New Build (Projections)

Projections for the expansion of nuclear power around the globe have been increasing steadily over the past few years, while reality shows a reverse trend. As the IAEA put it in a press release[106]: "The IAEA has revised upwards its nuclear power generation projections to 2030, while at the same time it reported that nuclear’s share of global electricity generation dropped another percentage point in 2007 to 14%." The trend continued in 2008:

- For the first time in nuclear power history, no start-up has been reported in the world;
- With 436 units the total number operating reactors is 8 less than 2002;
- Uprating, the increase of installed capacity by technical means at existing plants, has not been sufficient to compensate for the loss of the capacity of three units that were shut down for good[107], so the total installed nuclear capacity in the world decreased;
- A quarter of the units listed by the IAEA as "under construction" have been listed there for over 20 years;
- A quarter of the units listed by the IAEA as "under construction" are located in China, all but 5 are in Asia and Eastern Europe;
- Most of the units listed by the IAEA as "under construction" have encountered serious delays and/or are seriously over budget, except for those that either just started and/or where no information on the status is available (China, India, Russia…). As indicated before, these include in particular the units under construction by the French nuclear industry in Finland and France.

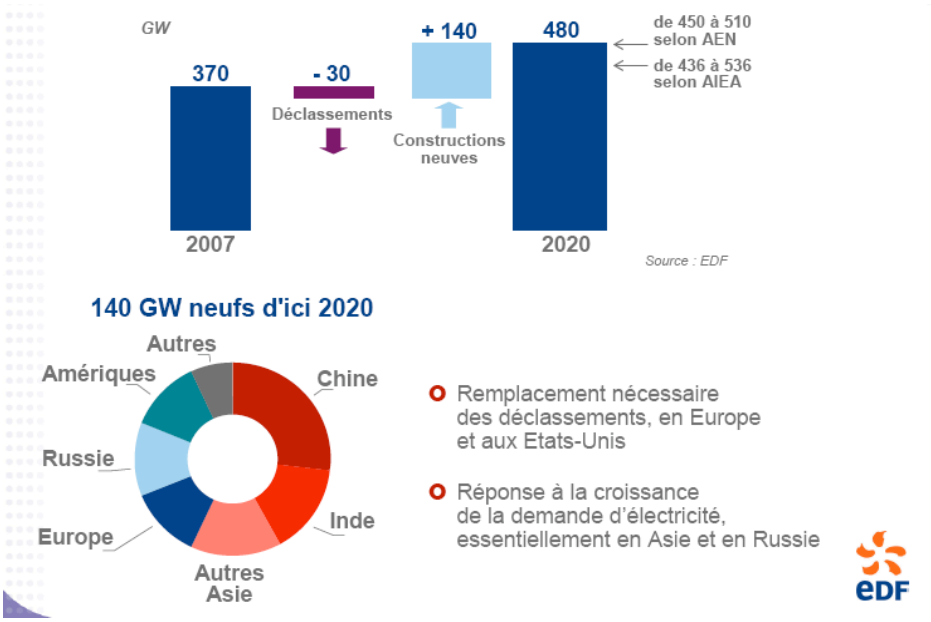
[103] His statement is actually historically incorrect. De Gaulle was certainly instrumental in the launch of the nuclear weapons program but the large civil nuclear program was launched in March 1974 under President Georges Pompidou and Prime Minister Pierre Messmer.
[104] Louis Armand, op.cit.
[105] Joschka Fischer, "The New Nuclear Risk", The Guardian, 30 March 2008, http://commentisfree.guardian.co.uk/joschka_fischer/2008/03/new_nuclear_risk.html
[106] IAEA, Press Release, 11 September 2008
[107] Hamaoka-1 and -2 in Japan and Bohunice-2 in Slovakia.

- Many of the additional projects, in particular those in the planning stage in the U.S., have been postponed repeatedly, some have been already abandoned entirely.

The French nuclear industry relies on projections by the OECD's Nuclear Energy Agency and the IAEA. The empirical trend summed up above raises serious doubts about the degree realism of these projections. However, until 2020 EDF projects 30 GW to be taken off the grid and 140 GW new build (see following figure).

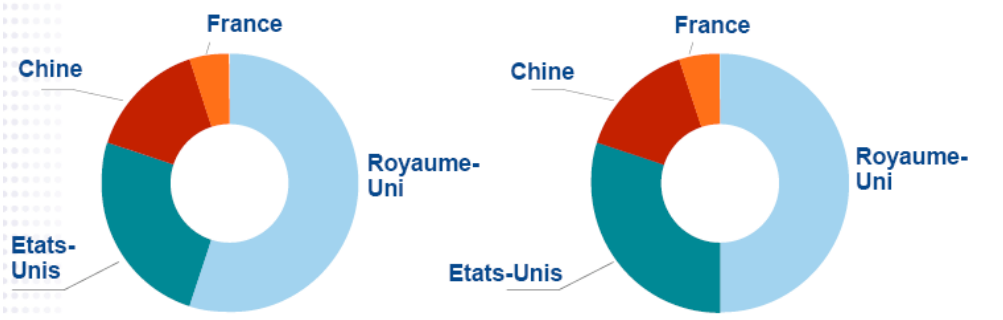
EDF projects a total investment in new nuclear power plant project between €40 and €50 billion until 2020. It is remarkable that over half of the expected investment is supposed to be carried out in the U.K.. In December 2008, the European Commission granted approval under the EU Merger Regulation and on 5 January 2009 EDF finalized its £12.5bn ($18.3bn) takeover of British Energy, operator of eight UK nuclear power plants. EDF envisages the construction of up to four new EPRs in the U.K.. EDF CEO Pierre Gadonneix stated immediately after the takeover that it was a matter of appropriate regulatory environment to reach the targets: "If we want to meet the 2017 challenge for the first EPR we must find ways to make the process as fluent as possible . . . That will take time, and that will cost."[108] An assessment commissioned by the U.K. Government concluded that the licensing procedure and its preparation could lead to substantial delays. "Preparation will be far longer than the IPC [Infrastructure Planning Commission] process, and could take years rather than months".[109]

Figure 7: EDF Projections for New Build Until 2020 (+140 GW)



Source: EDF

Figure 8: EDF Investment Projections for New Build Until 2020



Low Scenario €40 billion$_{2008}$ **High Scenario €50 billion$_{2008}$**

Source: EDF

[108] Financial Times, "EDF calls for greater 'fluency' from Britain in nuclear process", 6 January 2009
[109] Ian Trehearne, Tim Pugh, "The Infrastructure Planning Commission and the development of a new generation of Nuclear Power Stations", Berwin, 16 October 2008

The British Energy (BE) takeover by EDF raises a number of other questions, as pointed out by nuclear consultant David Lowry in a contribution to the British daily, *The Guardian*:

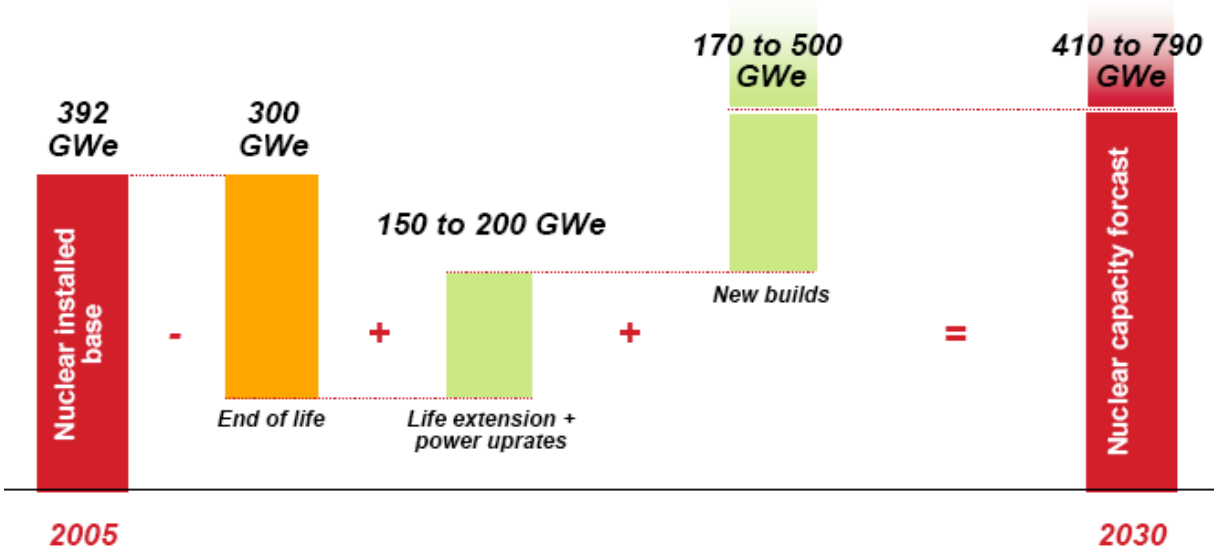
> So who will now be responsible for the clean-up of existing BE sites. If land is transferred from BE to other atomic aspirant owners, who will hold the liabilities for radioactive remediation? Who will be responsible for the insurance cover of existing reactors, especially any accident that involves off-site radioactive contamination. And who becomes responsible for other assets or liabilities of around 15,000kg (15 tonnes) of plutonium from BE's advanced gas-cooled reactors (AGRs) and the spent nuclear fuel discharged from the reactors?[110]

One could add the question on who will pay for decommissioning of the old British Energy plants that EDF took over. These issues could have a very significant impact on the cost calculation of the French involvement in the UK nuclear industry, for both sides, EDF and the British taxpayer. Answers have not been provided so far, by either industry or government.

In the short term, the most difficult challenge for EDF will be to find enough skilled workers to operate its new nuclear reactor fleet, not to talk about new build. The U.K. is facing a dramatic shortage of engineers of all sorts and practically all of the former university chairs for higher nuclear education have disappeared. Skilled nuclear workers are scarce.

AREVA's projections are even more ambitious and estimate a possible new build capacity between 170 GW and 500 GW by 2030.

Figure 9: AREVA's Projections for Installed Nuclear Capacity by 2030



Source: AREVA, Poncelet, "Nuclear Renaissance: What is at stake for Europe?", 14 November 2007

The **CEA** considers that "the [world] market for new nuclear plants can be estimated to 200 to 400 GWe worldwide, roughly one third could become reality in 'new nuclear countries'".[111] The range of all these "estimates" is amazingly wide, and the share envisaged in "newcomer" countries large[112]. Didier Kechemair, Deputy Director of International Relations describes the potential role for the CEA:

> At what stages of the decision making process can we work together? The preliminary phase must remain a diplomatic one, leading to intergovernmental validation of the collaboration. The last phase will hopefully be an industrial project with commercial contracts. In-between, pre-feasibility and feasibility phases,

[110] David Lowry, "Could nuclear sell-off be another taxpayer bail-out?", The Guardian, 19 November 2008
[111] Didier Kechemair, Deputy Director of International Relations, CEA News, January 2008; however, Kechemair does not indicate any timeframe.
[112] AREVA's CEO has estimated the share of newcomer countries in the new build market between 10% and 20%. see Axel Poniatowski, "Report of the National Assembly's Enquiry Committee on the Conditions of the Liberation of the Bulgarian Nurses and Doctor Withheld in Libya and the Recent Franco-Libyan Agreements", 22 January 2008

leading to “Call for Bids” milestone, give the opportunity of a structured bilateral partnership.

On which key-issues in the decision-making process can we work together? Development of an electronuclear project requires a plan for sustainable development (including analysis of economic and environmental advantages), a long-term government commitment (in particular regarding security, radiological protection and nuclear safety), and finally gives an opportunity to share international experience. As an example, the legal and regulatory framework is specific of each country, however it has to be up to the common international standards; other example: looking forward in 2020, early trained people will be managers of the nuclear program; human resources training has therefore to be seen as an asset, and it can be managed through international partnership.

In order to assist with the preparation of the first phase after the conclusion of the appropriate inter-governmental framework, in June 2008 the government set up the the Agence France Nucléaire International (AFNI) within the CEA. According to Philippe Pallier, director of AFNI, France received requests by "several tens of countries" for assistance to implement a civil nuclear power program.[113] He names specifically Algeria, Jordan, Libya, Morocco, Thailand, Tunisia, United Arab Emirates and Vietnam. As a first step AFNI offers legal support on nuclear legislation and to prepare for the signature of international nuclear treaties, creation of nuclear safety authorities, risk assessments and training of the engineers that will eventually manage the nuclear establishment. AFNI will coordinate nuclear competence available not only within the CEA but also the nuclear waste agency ANDRA, the Nuclear Safety Authorities and its technical backup the Institute for Radiation Protection and Nuclear Safety (IRSN).

The concept is basically that AFNI prepares the terrain for the nuclear industry. Historically, the CEA has already played that role.

The Way to the Nuclear Agreement With Libya

A good recent example of the procedure leading to a nuclear cooperation agreement is the case of the framework agreement with Libya. A brief chronology:[114]

• 25 November 2004: The Colonel Kadhafi requests assistance in the development of Libya's civil nuclear capacities during the official visit of President Chirac.

• December 2004: The CEA's General Administrator receives a phone call by François Loos, then Minister of Trade[115] who wishes that the CEA "rapidly" organizes a mission to Libya in order to establish contacts.

• 4 February 2005: An inter-ministerial group under the auspices of the Foreign Ministry meets and concludes that Libya's decision to conform with its international obligations[116] was "a satisfactory base to envisage international cooperation". The terms of reference for the CEA mission to Libya were defined: analysis of Libyan needs, state of Libya's facilities, identification of possible cooperation areas, but not the negotiation of a bilateral agreement.

• 11-14 April 2005: CEA mission to Libya. The Libyan counterparts transmit a draft memorandum of understanding (MOU). The CEA identifies two potential areas for cooperation, desalination of sea water and medical isotope production.

• 31 May 2005: The spokesperson of the French Ministry of Foreign Affairs mentions the ongoing negotiations during a press conference.

[113] Audio statement at http://www.cea.fr/presse/liste_des_communiques/philippe_pallier_est_nomme_directeur_de_l_afni

[114] The account is mainly based on oral evidence presented by Alain Bugat, then General Administrator of the CEA, to the National Assembly's Enquiry Committee on the Conditions of the Liberation of the Bulgarian Nurses and Doctor Withheld in Libya and the Recent Franco-Libyan Agreements", on 6 December 2007; see Report of the Enquiry Committee, dated 22 January 2008

[115] and member of the *Corps des Mines*

[116] In 2003 Libya had revealed that it had been working for years at a clandestine nuclear weapons program, in clear violation of its engagements as a signatory of the Non-Proliferation Treaty.

• June 2005: The U.S. authorities are informed of the ongoing negotiations.

• August 2005: At the request of the French Foreign Ministry and in response of the Libyan draft MOU, the CEA had elaborated a French draft and transmits it to the Libyan side. The goal was to sign it during the IAEA's Annual Conference, which the Libyan side did not wish to do.

• 14-16 March 2006: Visit of the CEA's General Administrator in Tripoli and signature of the MOU.

• August 2006: Cis Bio, company specializing in radio-isotope production visits Libya.

• 24 January 2007: AREVA's CEO Anne Lauvergeon welcomes a Libyan delegation.

• 3-4 July 2007: Agreement on the modalities of the training of Libyan experts by Cis-Bio. Presentation by the CEA's Director of International Relations "on the indispensable pre-requisites of a safe and responsible development of nuclear energy". The Libyan side "clearly" indicates their interest for the French EPR.

• 25 July 2007: Signature during the visit of President Sarkozy in Tripoli of the MOU defining the goal of an agreement on the development of nuclear energy for peaceful purposes.

• 10 December 2007: Provisional signature[117]of the agreement during the visit of Colonel Kadhafi in Paris.

• 8 July 2008: Formal signature of the Cooperation Agreement on the Development of Nuclear Energy for Peaceful Purposes by the French Secretary of State for Cooperation Alain Joyandet and the Libyan Minister for European Affairs Abdelaati Ibrahim El Obeidi.

According to the French Ministry of Foreign Affairs the cooperation agreement with Libya, "comparable to the agreements signed recently with other partners of France"[118], includes the following areas:

- basic and applied research;
- nuclear energy applications in agriculture, biology, natural sciences, medicine and industry;
- production of electrical energy and desalanisation;
- exploration and exploitation of uranium deposits;
- management of nuclear fuel and wastes;
- nuclear safety, radiation and environmental protection;
- accident prevention and remediation;
- public information "in view of the acceptance of nuclear energy".

It is remarkable that AREVA already, prior to any formal government agreement, had initiated direct contacts with Libyan officials to discuss the potential development of a nuclear energy program. AREVA's CEO told a French Parliamentary Enquiry Committee: "For us the Libyan approach is absolutely normal. In fact, we host, week after week, numerous delegations from different countries that ask us how to develop or re-develop nuclear energy".[119]

AREVA's official criteria for investing in new countries are[120]

- Existing nuclear activities;
- Industrial skills;
- Competitive costs;
- Where AREVA's local market share is high enough.

In addition, AREVA's CEO has stated that the group would only "work in countries and with utilities that accept Full Scope Safeguards of the IAEA."[121]

[117] The term used by the French Ministry of Foreign Affairs is "paraphé dans un premier temps". It means that the agreement is conditional upon the agreement of EURATOM. see http://www.diplomatie.gouv.fr/fr/pays-zones-geo_833/libye_409/france-libye_1176/presentation_4528/cooperation-energetique-avec-libye-08.07.08_64322.html

[118] http://www.diplomatie.gouv.fr op.cit.

[119] Axel Poniatowski, op.cit.

[120] David Whittal, "AREVA: Making the Nuclear Renaissance a Certainty", 14 February 2008

In February 2008, AREVA had identified the ideal case for a new market for its EPR technology. "The timing is perfect for South Africa: AREVA is making its investment decisions now."[122] South Africa is not a newcomer country and it already operates two reactors supplied by the French industry. However, in December 2008 the South African utility ESKOM cancelled the bidding process, "due to the magnitude of the investment".[123] Whether the South African project became a victim to the international credit crunch or to the excessive costs of the nuclear industry's products is a matter of interpretation. But if not South Africa, who then?

Conclusions

The State owned French nuclear industry is the most powerful nuclear player in the world. It controls significant market shares in all business areas from uranium mining to nuclear waste management. The development towards this position has been possible because it was designed and implemented by a small technocratic elite that operates outside of election considerations and democratic control. The French nuclear industry also profits from a unique fuel chain that does not distinguish between civil and military uses.

Whether the French nuclear industry will succeed in boosting reactor sales and exporting its nuclear model to other countries remains to be seen: however, at this point it seems highly unlikely. AREVA, the world's largest nuclear builder has not demonstrated yet that it is able to build new nuclear power plants to date and to budget. On the contrary, current projects have been delayed repeatedly, construction costs have exploded and several planned exports have been shelved or postponed. The credit crunch and subsequent world economic crisis will rather exacerbate than alleviate difficulties. Capital is rare and expensive. And the drop in consumption in many countries has relieved a lot of the pressure for more electricity capacity. In addition, over the last decade the electricity industry has generated a number of very powerful and effective competitors.[124]

France's past history on nuclear proliferation raises questions as to the potential fallout from recent nuclear cooperation agreements. Over the past 50 years France has generously offered nuclear technology, soft and hardware, facilities and special nuclear materials to numerous countries. Some countries have clearly profited from these transfers to build up their own nuclear weapons programs. While the implementation of new nuclear power plants remains highly unlikely in many of the countries relentlessly traveled by French industry and government officials carrying nuclear offers in their briefcases, transfer of nuclear know-how can start in the very short term and constitutes a serious proliferation concern.

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[121] Axel Poniatowski, op.cit.
[122] David Whittal, op.cit.
[123] ESKOM, Press Release, 5 December 2008
[124] For example, in 2008, with 8,500 MW new capacity connected to the EU grid, wind power for the first time outpaced all other sources, including natural gas. Nuclear power added 60 MW through uprating. Since 2000, wind added over 55,000 MW while nuclear power decreased by over 6,000 MW.

Annex 1: The *Corps des Mines* in Top Positions Relevant to Energy and Nuclear Policy

Note: The following listing of Corps des Mines representatives in the French top state administration and nuclear energy related companies has been established by the author in January 2009. It is by no means comprehensive. There is no public document that provides a position-by-position overview for the members of the Corps des Mines. Some of the Corps des Mines engineers have been erased from the Corps at their own request.[125]

- French Prime Minister's Office
  - Advisor for Sustainable Development, Research & Industry[126]
  - Advisor for Company Financing, Services, Crafts, Competition, Consumption & Tourism[127]
  - Advisor for Industrial Strategies, Small & Medium Size Enterprises/Industries, Technologies & Information Society[128]
  - General Secretariat for National Defense, Director for Technology and Strategic Controls Technology[129]
  - Center for Strategic Analysis, President of the Energy Commission[130]
  - Inter-ministerial Delegate for Sustainable Development
    - Advisor on Energy Systems[131]
- Office of the Minister for the Economy, Industry and Employment
  - Assistant-Director
- Office of the Minister of State to the Minister for the Economy, Industry and Employment, with responsibility for Industry and Consumer Affairs - Government Spokesman
  - Director[132]
  - Regional Directorate for Industry, Research and Environment (DRIRE)
    - Director[133]
- Ministry for Ecology, Energy, Sustainable Development and Town and Country Planning (Regional Development)
  - Advisor for Energy & Climate[134]
  - Advisor for Nuclear & Environmental Safety[135]
  - General Director for Energy and Climate (DGEC)[136]
    - Director for Energy[137]
      - Assistant Director for Nuclear Energy[138]
- French Embassy, London, Nuclear Counselor[139]
- French Nuclear Safety Authority (ASN)
  - President[140]
  - Member[141]

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[125] Some members quit their Corps status in order to get a higher salary. The salary as a Corps member is capped. Others quit because they reach the time limit of being "detached" (détaché) from their attributed public position.

[126] François Jacq

[127] Frank Demaille

[128] Yohann Leroy

[129] Jean Luc Vo Van Qui

[130] Jean Syrota

[131] Tristan Mocilnikar

[132] Marc Mortureux

[133] Philippe Ledenvic in the case of the DRIRE Rhône-Alpes, for example; DRIRE directors are the regional representatives of the Ministries of Industry, Research and Ecology but also the representatives of the Nuclear Safety Authority. Historically, they have been members of the *Corps des Mines*.

[134] Youenn Dupuis

[135] Olivier Terneaud

[136] Pierre-Franck Chevet

[137] Pierre-Marie Abadie

[138] Cyrille Vincent

[139] Alain Régent

[140] André-Claude Lacoste

[141] Jean-Rémi Gouze

- National Radioactive Waste Management Agency (ANDRA)
  - Director General[142]
  - Member of the Board of Directors[143]

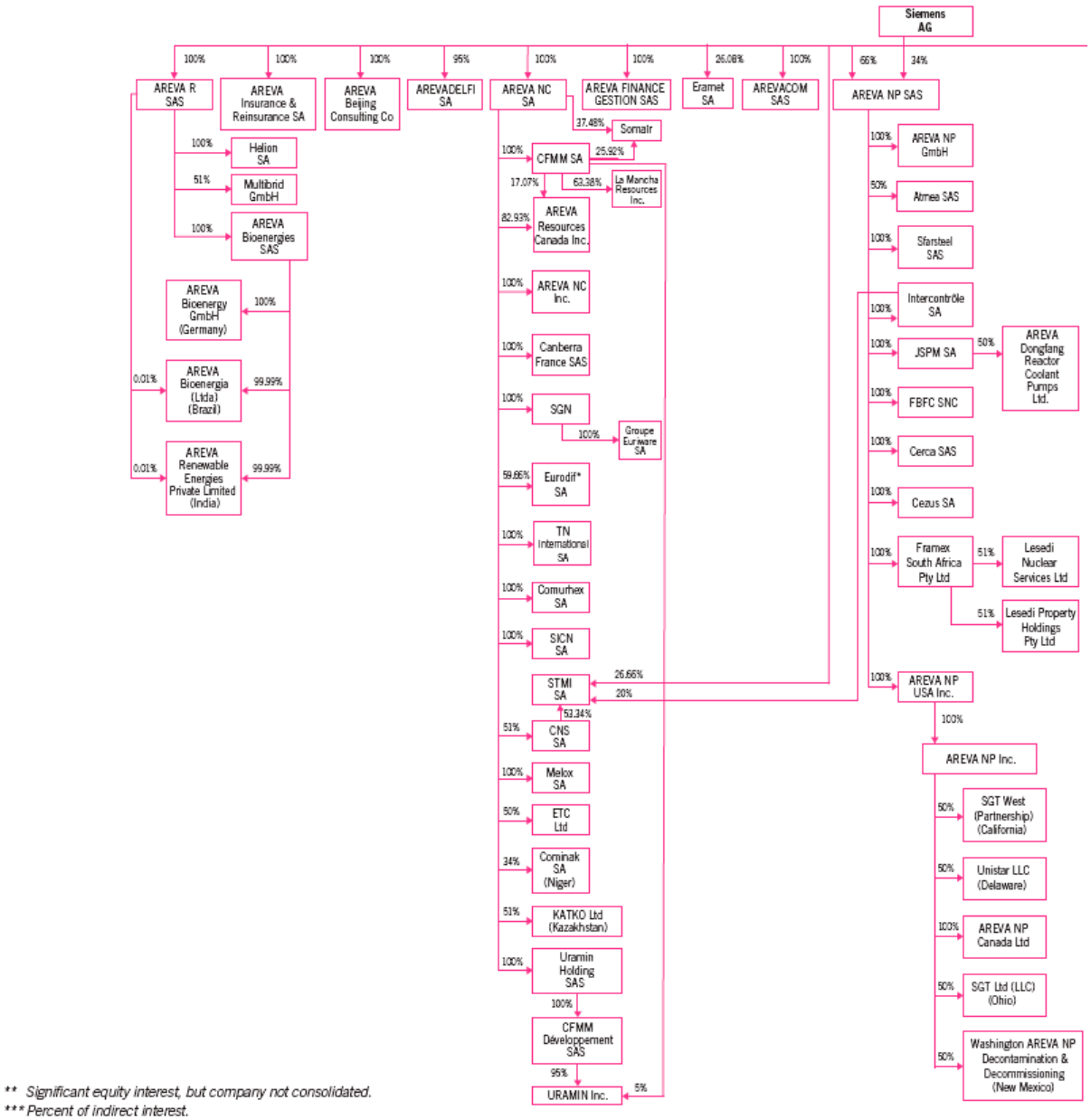
- Alsthom, CEO[144]
- AREVA
  - CEO[145]
  - Members of the Board of Directors[146]
  - Members of the Surveillance Council[147]
- AREVA Inc., President[148]
- AREVA NC Inc., President & CEO[149]
  - SOFIDIF, CEO[150]
- AREVA NP
  - President[151]
  - Director of the Olkiluoto-3 project[152]
- BRGM (Bureau of Geological and Mining Research), President[153]
- CEA (Atomic Energy Commission)
  - Oversight Committee on Clean-up and Decommissioning of Civil Nuclear Facilities
    - Two members[154]
- EDF[155] (Electricité de France)
  - Assistant Director General for Production and Engineering[156]
- EDF Generation
  - Special Advisor for Nuclear R&D and International Affairs[157]
- EDF RTE (Réseau de distribution d'électricité)
  - President[158]
- Institute for Radiation Protection and Nuclear Safety (IRSN)
  - Director General[159]
  - Advisor to the Director General[160]
- National Center of Space Studies (CNES), President[161]
- Saint-Gobain, CEO[162]
- SFEN (French Society for Nuclear Energy), President[163]
-
-
-

[142] Marie-Claude Dupuis
[143] Yannick d'Escatha
[144] Patrick Kron
[145] Anne Lauvergeon
[146] 2 out of 5: the CEO and the President of AREVA NP
[147] At least 2 out of 15: Thierry Desmarest and Pierre-Franck Chevet
[148] Jacques Besnainou
[149] Jacques Besnainou
[150] Christian Gobert
[151] Luc Oursel
[152] Philippe Knoche
[153] Philippe Vesseron
[154] Philippe Saint-Raymond and Cyrille Vincent
[155] Amongst the Top 20 EDF executives presented on 20 March 2006 by CEO Gadonneix (including himself) there are 5 Polytechnique graduates of whom one is *Corps des Mines*.
[156] Bernard Dupraz
[157] Noël Camarcat
[158] Dominique Maillard
[159] Jacques Repussard
[160] Daniel Quéniart
[161] Yannick d'Escatha
[162] Jean-Louis Beffa
[163] Noël Camarcat

- Suez
  - Director for Strategy[164]
  - Director General of Lyonaise des Eaux[165]
- Total
  - Board
    - President[166]
    - Honorary President[167]
    - Members[168]
  - Department Gas and New Energies
    - Director General[169]
      - Nuclear Advisor[170]
  - Department for Sustainable Development and Environment
    - Director[171]

[164] Bruno Bensasson, 35 years young, a typical "miner" career: Nuclear Safety Authority, then Nuclear Advisor to the Industry Minister, then Advisor for Environment, Industry and Transport to the President of the Republic, before he took up the position at Suez in September 2007
[165] Isabelle Kocher, former Advisor for Industrial Affairs to the French Prime Minister, she perfectly complements the career experience of her colleague Bruno Bensasson
[166] Thierry Desmarest
[167] Jacques Puéchal
[168] at least 7 out of 16: Thierry Desmarest, Anne Lauvergeon, Claude Mandil, Christophe de Margerie, Michel Pébereau, Serge Tchuruk, Pierre Vaillaud
[169] Philippe Boisseau
[170] Bernard Estève was hired in September 2008, following the decision by the Group to develop its activities in the nuclear sector.
[171] Jean-Michel Gires

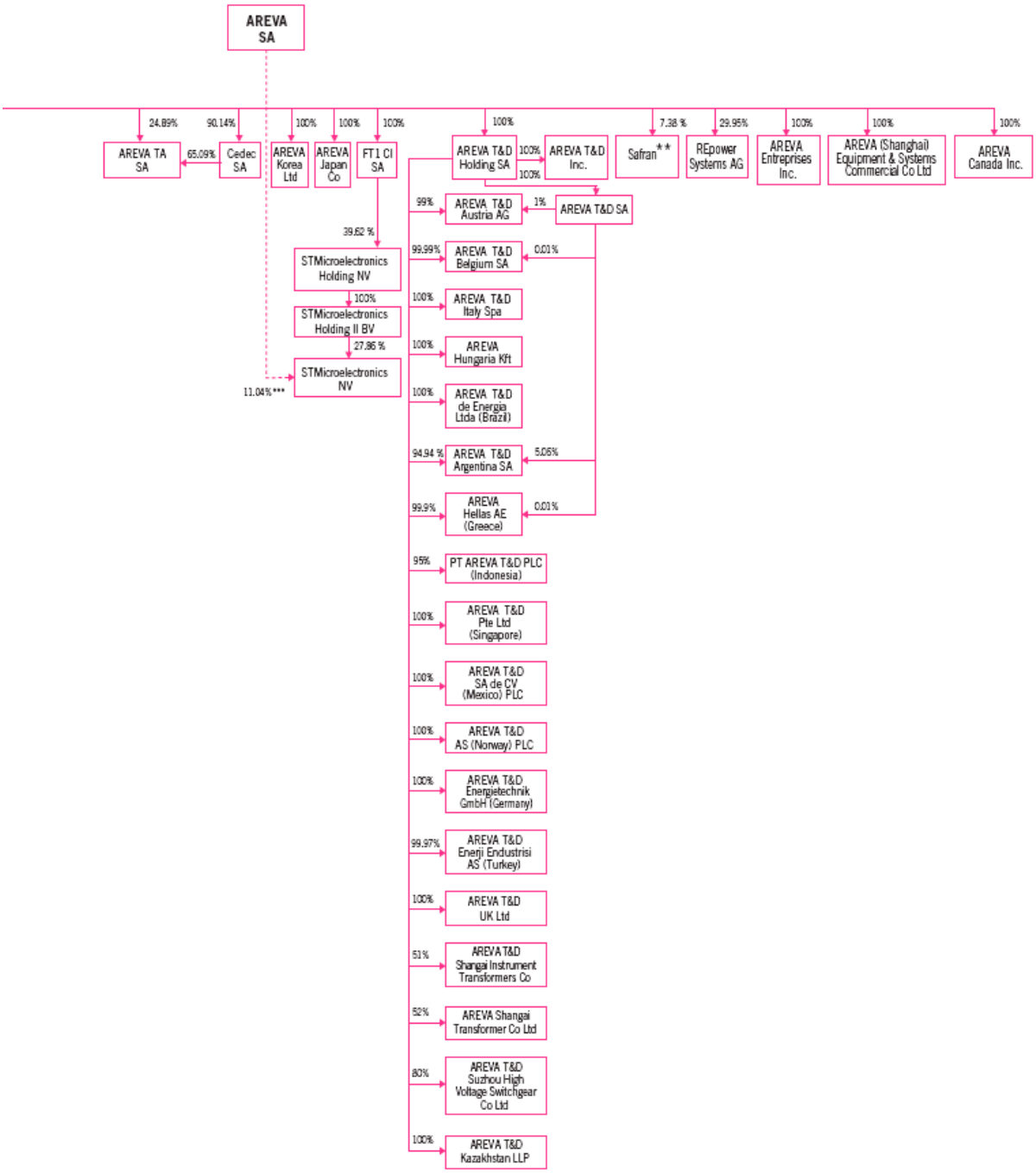
Annex 2: AREVA Companies (as of 31 March 2008)[172]



** Significant equity interest, but company not consolidated.
*** Percent of indirect interest.

* Eurodif SA: direct and indirect equity interest via Solidif.

[172] AREVA, Reference Document 2007, 2008


AREVA SA
24.89%
90.14%
100%
100%
100%
100%
7.38 %
29.95%
100%
100%
100%
AREVA TA SA
65.09%
Cedec SA
AREVA Korea Ltd
AREVA Japan Co
FT1 CI SA
AREVA T&D Holding SA
100%
100%
AREVA T&D Inc.
Safran**
REpower Systems AG
AREVA Entreprises Inc.
AREVA (Shanghai) Equipment & Systems Commercial Co Ltd
AREVA Canada Inc.
99%
1%
AREVA T&D Austria AG
AREVA T&D SA
39.62 %
99.99%
0.01%
AREVA T&D Belgium SA
STMicroelectronics Holding NV
100%
AREVA T&D Italy Spa
STMicroelectronics Holding II BV
27.86 %
100%
AREVA Hungaria Kft
11.04%***
STMicroelectronics NV
100%
AREVA T&D de Energia Ltda (Brazil)
94.94 %
5.06%
AREVA T&D Argentina SA
99.9%
0.01%
AREVA Hellas AE (Greece)
95%
PT AREVA T&D PLC (Indonesia)
100%
AREVA T&D Pte Ltd (Singapore)
100%
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