DIIS REPORT

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Governing Uranium in France

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INTRODUCTION

Although much has been written and debated about nuclear energy, little is available on *governing* nuclear energy. The same remark must be made about uranium: there is abundant technical or economic literature on it, but its governance has not been studied in its own right but often as a side effect of non-proliferation studies. This is even more the case concerning uranium in the early stages of the fuel cycle – which for the purposes of this paper means up to the point of conversion – as this mostly lies outside of the traditional focus of non-proliferation studies, which concentrate on the later steps. In the same way, safety concerns, at least in the public mind, tend to focus attention much more on highly radioactive materials: the fact is that 'the risk for a nuclear criticality event can be considered as totally excluded for natural uranium'.[1]

The renewed interest in natural uranium is an effect of the growing international focus on nuclear security. In this context, even though 'the trade in stolen uranium is as old as the nuclear era', each link in the supply chain is being re-examined from a security point of view, and natural uranium more than the others, as international rules are less stringent regarding this first stage of the nuclear fuel cycle, for reasons mentioned below.

'Re-examined': words matter. This paper is not an indictment of the supposed absence of sufficient rules in the early stages of the nuclear fuel cycle. Instead it aims to assess the rules and dynamics of the governance of natural uranium in France without any preconceptions. That means describing the political and regulatory framework that governs this material from a historical perspective. It will therefore not cover the technical aspects of uranium.

The task is a demanding one.

First, as noted, we are rendered blind by the absence of research in this area, as little has been written on the topic of the governance of natural uranium. If data exists, it is, dispersed, requiring a huge work of consolidation. Similarly, terminology issues are a source of significant complexity in this research, starting with the very word 'uranium' itself. Isolating specific pieces of legislation related to natural uranium is indeed not

1 Henri Métivier (coord.), L'uranium, de l'environnement à l'homme, EDP Sciences, Les Ulis, 2001, p. 116.

always easy, as French law refers to the concept of 'nuclear material' (Defense Code), a wider meaning than the definition contained in the 1979 Convention on the Physical Protection of Nuclear Material (CPPNM). According to French legislation, this covers plutonium and uranium, as well as thorium, deuterium, tritium and lithium 6, and the chemical compounds containing any of these elements, with the exception of ores. As for natural uranium, this generally refers to oxide or uranate, the form in which it is imported into France.

Secondly, because the issue of nuclear governance in general is complex, especially as France has extensively revised its regulations in the past decade. This has happened in the wake of the relative liberalization of the nuclear sector, which has given increased autonomy to the nuclear industry vis-à-vis the French state, and of the sector's internationalization as well as the renewed threat of terrorism.

Thirdly, there is the weight of secrecy – which is still strong in the nuclear world in spite of the major improvements made to transparency and even more so on security issues – the difference being that secrecy is to a certain extent consubstantial with security, but has sometimes tended to pervade the field of safety.

The last reason accounting for this difficulty is that, even though it is imported from many other countries, natural uranium in France is immediately associated with its relationship with African countries, the 'uranium archipelago that France used to manage'.[2] It has always fed rumours, myths and theories of plots with the stories of the 'Françafrique' in the background. And 'uranium' – or to be more accurate the fear it raises – was a key part of the American justification for invading Iraq in March 2003',[3] uranium that appeared to come from Niger. The very current and sensitive security situation in the Sahel region, where human lives are at risk, has a double impact on the security issue: on the one hand, it further enhances the relevance of questioning the governance of uranium; on the other hand, the time is ripe for action.

Research must find its way through this complex situation and give back to the social sciences – to law, history, political science – what has too often been left to mythology and passions.

2 These words are Tom Zoellner's: see Uranium: la biographie, Seuil, Paris, 2009, p. 227.
3 Tom Zoellner, op. cit., p. 188.

To grasp the governance of uranium in France, this paper will first trace the history of France's constant quest for uranium and assess the country's past and current status on uranium. We will then explain the rationale of the recent re-engineering of the governance of the French nuclear system and see its consequences for mapping the different players and stakeholders involved. The third part will be dedicated to the French regulation of natural uranium, including its foreign-policy dimension, at each stage: importation, transportation, storage and export.

I. FRANCE AND URANIUM: THE STORY OF A QUEST

Characterizing France's status regarding natural uranium has never been simple. The first kilos of natural uranium on French soil came from abroad, and even after domestic production was started, natural uranium has continued to be imported. This complex status derives from the fact that natural uranium enjoys two different roles in France's view: first, as a strategic raw material, vital for both its civil and military nuclear programs; and secondly, a commodity which participated in shaping France's status as a major commercial nuclear power, willing to retain a leading role in trading nuclear materials, technologies and services through major international companies.

The early years

In May 1939, on the initiative of Frédéric Joliot-Curie, the Union Minière du Haut Katanga, a Belgian company operating in Congo, lent eight tons of uranium oxide (U3O8) to France's Centre National de la Recherche Scientifique (CNRS). France also bought 400 kilos (880 pounds) of uranium metal from the United States in 1939. Deliveries of the Belgian uranium were made in June 1939 and March 1940. In June, due to the advance of the German army, part of that uranium was secretly sent to French Morocco and hidden in a mine.

By December 1944, the United Kingdom and the United States had secured all future Katanga uranium production. In April 1946, after the creation of the Commissariat à l'Energie Atomique (CEA, 1945), the French stockpile was repatriated from Morocco. The CEA also benefitted from several tons of sodium uranate (the equivalent of three tonnes of uranium dioxide) of Belgian origin which had been found in a train wagon at Le Havre at Liberation. The CEA decided to purify the uranium oxide that had been repatriated from Morocco, which was of a much better quality than the materials found at Le Havre.[4]

4 On the 1939-1946 events, see Bertrand Goldchmidt, L'Aventure atomique, Paris, Fayard, 1962, p. 76; Bertrand Goldschmidt, Les Rivalités atomiques 1939-1966, Paris, Fayard, 1967, p. 181; Bertrand Goldschmidt, Pionniers de l'atome, Paris, Stock, 1987, pp. 73-79, p. 364; Dominique Mongin, La Bombe atomique française 1945-1958, Bruxelles, Bruylant et LGDJ, 1997, p. 23, p. 47; and Jeffrey Richelson, Spying on the Bomb: American Intelligence from Nazi Germany to Iran and North Korea, updated edition, New York, W.W. Norton & Co., 2007, pp. 196-197.

Production of uranium metal began in October 1947.[5] By December 1948, France began operating a small, zero-power, heavy water-moderated reactor. In 1949, one tonne of uranium metal was produced.[6]

In October 1951, Paris confirmed that it would embark on the natural uranium / graphite-gas route. At that time, the country had neither the resources nor the know-how to enrich uranium.[7] In January 1956, the first graphite-gas reactor became operational (G1, with a power of 46 MWth / 2 MWe). Two other reactors (G2 and G3, each with a power of 250 MWth / 38 MWe), using natural uranium, entered service in 1958 and 1959, each needing 100 tons of uranium.[8] The first two were fuelled with the uranium that the CEA had acquired in 1946.[9]

Immediately after its creation in October 1945, the CEA set up a Prospection School at the Museum of Natural History. In 1948, it launched a major prospection effort in France. Initial discoveries at La Crouzille (Limousin) in November of that year were promising, with ores of a concentration of 2-10%. In 1949, production amounted to 75 tonnes. By 1953, the CEA had turned to chemical (as opposed to physical) treatment of the ore. In 1955, the French government authorized private mining, thus ending the CEA's monopoly and permitting a rapid increase in production. By 1958, France had produced a total of 1,823 tonnes of uranium on its territory.[10]

In 1958, the CEA built a new conversion plant at Malvesi (inaugurated in 1969), releasing the CEA center at Le Bouchet, which had been operating since 1948, for special or complementary production. After Le Bouchet was closed in 1971, Malvesi became the only operating conversion plant in France.[11]

5 Mongin, op. cit., p. 104.
6 Mary Bird Davis, La France nucléaire: matières et sites 2002, Paris, WISE-Paris, 2001, p. 166.
7 Mongin, op. cit., p. 137. HEU production at Pierrelatte began in 1967 for military purposes, and in 1972 for both civilian and military purposes. Davis, op., cit., p. 77.
8 Jean Ginier, « L'énergie nucléaire en France », L'information géographique, vol. 29, n° 1, 1965, p. 16.
9 Goldschmidt, Les Rivalités atomiques, op. cit., p. 182 ; Goldschmidt, Pionniers de l'atome, op. cit., p. 365.
10 Jacques Blanc, Les mines d'uranium et leurs mineurs français: une belle aventure , Réalités industrielles, août 2008, p. 38.
11 It was estimated in 2001 that Le Bouchet had treated about 9.500 tons of natural uranium and produced (until 1971) a total of about 4.000 tons of uranium metal for research and power reactors. Davis, op. cit., p. 166.

Searching for foreign sources

Despite the growing investment in domestic resources, France exploited foreign sources of uranium very early, for a variety of successive reasons.

It was realized early on that France's ambitious nuclear program would require a very significant quantity of uranium. There was no certainty that domestic sources would fulfill all French needs, both civilian (research, electricity) and military (propulsion, weapons). Well before the massive expansion of the power plants program in the mid-1970s, Paris knew that its civilian needs would exceed available resources in France, Madagascar and Gabon.[12]

Furthermore, French uranium was expensive to produce. By the late 1950s, the richest ores (1-10%) had been mined. The remainder contained only a low proportion of ore (0.1 to 1%).[13] Paris sought to buy uranium from Canada in 1957 as an alternative to opening a new mine and treatment plant; only when the sale failed (see below) did France resolve to increase its production.[14] In the ensuing years (1959-1960), severe national economic difficulties limited investment in mining.

By 1960, France faced a risk of overproduction. The economic crisis had slowed down the power plants program, and the US decision to terminate its foreign contracts (due to the discovery of new domestic resources) led to a fall in the price of foreign uranium, making access to the market even more attractive. Finally, there was a desire to maintain domestic reserves.[15]

For these reasons, production in the 1960s was limited to 1,200-1,600 tonnes per year.[16] Until 1972 it never exceeded 1,400 tonnes, and extraction stayed well below maximum capacity.[17]

A different reason for seeking foreign sources emerged in the late 1960s: Paris sought to become a global supplier of uranium. Until then, France had only sold small quantities (between ten and forty tonnes in each case) of natural uranium to

12 Goldschmidt, Les Rivalités atomiques, op. cit., p. 278.
13 Davis, op. cit., p. 73.
14 Goldschmidt, L'Aventure atomique, op. cit., p. 168.
15 See Gabrielle Hecht, Being Nuclear: Africans and the Global Uranium Trade, Cambridge, MIT Press, 2012, and Blanc, op. cit.
16 1,200 according to Blanc, op. cit., p. 38; 1,600 according to Ginier, op. cit., p. 14.
17 Organization for Economic Cooperation and Development (OECD) / International Atomic Energy Agency (IAEA), Forty Years of Uranium Demand, Production and Perspectives, Paris, OECD, 2006, p. 103.

countries such as Denmark, India and Sweden.[18] (In addition, a few short tons were reportedly sold to Israel in the 1960s.[19]) In 1969, the URANEX company was set up for that purpose by the CEA and private companies. Its ambition was to sell no less than 24,000 tonnes of uranium oxide between 1970 and 1974.[20] Major exports began in 1972, and even though the launch of the power plants program would curtail sales abroad, France began to sell significant quantities of natural uranium to Western countries such as Belgium, Japan and Sweden. Starting from 200 tons in 1972, exports reached 3,050tU of UOC in 1978.[21]

During the EURATOM negotiations (1955-1957), France insisted on equal access to resources and priority of supply to European Community members: at that time, Paris was interested in accessing uranium in the Belgium Congo after long-term contracts with Anglo-Saxon countries ended in 1960. These efforts succeeded, but ended up being useless given the large-scale sources of uranium that had been discovered by that time.[22]

Foreign sources of uranium focused mostly on French colonies or former colonies. They included the following:

French or joint exploitation of foreign sources.

- *French Morocco* was initially thought to be a promising source. A secret US–French exploration program of potential resources was set up in 1952. Proving fruitless, it was abandoned in 1957.[23]

- *Madagascar* was the first promising location, and the CEA reportedly pressed the French government to avoid granting it early independence. However, it did not deliver much. France extracted uranium there from 1953 to 1968. Cumu-

18 Goldschmidt, L'Aventure atomique, op. cit., p. 244, p. 252; Goldschmidt, Le Complexe atomique: histoire politique de l'energie nucléaire, Fayard, 1980, pp. 301-302, p. 381. Paris refused, as a matter of principle and consistently with its policy on the uranium market, to include EURATOM safeguards in the 1959 contracts with Denmark and Sweden.

19 Peter Pry, Israel's Nuclear Arsenal, Westview, Boulder, 1984, p. 24; Dan Raviv and Yossi Melman, Spies Against Armageddon, Sea Cliff: Levant Books, 2012, p. 146.

20 Hecht, op. cit., p. 69.

21 Thomas L. Neff and Henry D. Jacoby, The International Uranium Market, MIT Energy Laboratory Report No. MIT-EL 80-014, December 1980, pp. 5-13.

22 Bertrand Goldchmidt, Le Complexe atomique : histoire politique de l'énergie nucléaire, Paris, Fayard, 1980, pp. 310-311.

23 Goldschmidt, Le Complexe atomique, op. cit., p. 123.

lative production was 1,000 tonnes.[24] In 1956, a special thorianite workshop (dedicated to the production of thorium and uranium from the thorianite) was set up at the CEA.

- *Gabon* quickly became a major source. Initial discoveries in 1955-1957 led to exploitation of Gabonese mines from 1958 to 1999 by a French company created in 1958 for that purpose, called COMUF (Compagnie des mines d'uranium de Franceville, a joint CEA/CMF firm).[25] COMUF began sending uranium to France in 1961, preferential access having been given by a post-independence (1960) bilateral agreement (see below). Gabon took a 25% share in COMUF in 1974. A yellowcake mill was opened in 1982.[26] In total, COMUF produced more than 26,000 tonnes of uranium, with yearly production varying between 500 and 1,500 tonnes.[27]

- *Niger* was to become a prominent source and would remain one to this day. Discoveries started as early as 1956 and proved fruitful in 1964, after Nigerien independence (1960). By that time, France had secured preferred access to Nigerien uranium through an addendum to a 1961 defense agreement (see below). Two ad hoc French–Nigerien companies were created: SOMAÏR (Société des mines de l'Aïr, 1968) and COMINAK (Compagnie minière d'Akouta, 1974).[28] Production began in 1971.

- *Canada* too would later become an important supplier. In 1967, a joint CEA/CMF team made promising discoveries. Ore from Cluff Lake was exploited by COGEMA in the 1980s and 1990s, producing about 20,000 tonnes of uranium. Deliveries to France started in 1981 (520 tonnes), expanding to 750 tonnes yearly afterwards.[29]

24 Blanc, op. cit., p. 37.
25 Compagnie Française de Mokta (CFM) was a leading French uranium mining actor until it was absorbed by COGEMA in 1993.
26 Source for this para: Hecht, op. cit.
27 Areva website, accessed January 2013.
28 Today SOMAÏR is owned by Areva (63.6%) and the Nigerien State company SOPAMIN (36.4%); COMINAK is owned by Areva (34%), SOPAMIN (33%), the Japanese company OURD (25%), and the Spanish company ENUSA (10%). Areva website.
29 Neff and Jacoby, op. cit., pp. 5-11, Table A-21.

Imports from other countries

- *Mozambique.* In 1948, the CEA concluded an agreement with Portugal for the importation of 'a few tonnes' of uranium.[30]

- *South Africa.* As the United States discovered new resources on its own territory, it did not need to monopolize Belgian, Canadian or South African uranium. Paris therefore turned to these suppliers. In 1955 – simultaneously with the opening of the EURATOM discussions – negotiations with Belgium for a small quantity or uranium (20 tonnes) failed for price reasons.[31] In 1957 (and again in 1965), France failed to secure a contract to buy uranium from Canada for a renewable delivery of 1,000 tonnes.[32] By 1963, the CEA's contacts in Pretoria told the French that they would be ready to sell 'free of use' uranium. A contract was signed in 1964, reportedly representing almost two-thirds of French annual production (thus about 800 tonnes), for a price which was one-third of the price envisaged in the Canada contract.[33] This contract was followed by others; despite the growing number of French uranium sources, South African uranium was still of interest to Paris because it was low priced. South African supplies began in 1978, with 778tU being exported annually to France.[34]

By 1968, the total of natural uranium produced and imported by France since the late 1940s was estimated to be 16,850 tonnes.[35]

The first six commercial power plants became operational in France between 1966 and 1971, graphite-gas reactors using natural uranium. However, in November 1969, for economic reasons, France choose to embark on the PWR route favored by EDF rather

30 Goldschmidt, Les rivalités atomiques, op. cit., p. 185.

31 Bertrand Goldschmidt in Université de Franche-Comté / Institut Charles de Gaulle, L'aventure de la Bombe : de Gaulle et la dissuasion nucléaire, 1958-1969, Paris, Plon, 1985, p. 63 ; Goldschmidt, L'Aventure atomique, op. cit., p. 129.

32 The two options suggested by Paris were rejected. Due to US pressure, Canada did not want to sell 'free of use' uranium even at a high price, even though it sold no-strings-attached uranium to Washington and London. (Obtaining the same conditions was a matter of principle for Paris, which, as will be seen below, judged that it had enough domestic reserves for military purposes.) The other option for France was to buy safeguarded uranium for civilian purposes, but Ottawa could not sell at the price requested by the French (who sought a discount since the price asked by the Canadians was the same as the unsafeguarded uranium sold to the United States). On the Canada negotiations, see Bertrand Goldschmidt in Université de Franche-Comté / Institut Charles de Gaulle, op. cit., p. 64 ; Goldschmidt, Les Rivalités atomiques, op. cit., pp. 230-231, p. 278 ; Goldschmidt, Le Complexe atomique, op. cit., pp. 299-300.

33 Bertrand Goldschmidt, Le Complexe atomique, op. cit., p. 302 ; Les Rivalités atomiques, op. cit., pp. 230-231.

34 Neff and Jacoby, op. cit., pp. 5-11, Table A-23.

35 Neff and Jacoby, op. cit., pp. 5-11.

than continue with the graphite-gas route preferred by the CEA, which France had tried to impose on its European partners, though without success.[36] Consequently, Paris sought to increase its enrichment capability. EURODIF (the name referring to the choice of the gas diffusion method) consortium was created in November 1973. The adoption of PWR (under a Westinghouse license type) allowed for the separation of civilian and military activities.

The expansion of the power plants program and the shift to foreign supplies

The oil shock of 1973 changed the perspective, leading to a rapid and massive expansion of the power plants program and consequently of the demand for uranium. The French government created COGEMA (Compagnie Générale des Matières Nucléaires) in 1976 as an offshoot of the CEA. By 1977, EDF needs were 2, 500-3,000 tons of uranium and were rapidly increasing.[37] The government's 'Plan Uranium' sought to ensure that French production (domestic, as well as through shares in jointly owned companies operating abroad) would make the country self-sufficient. Starting in 1975, France imported more uranium from abroad than it produced on its territory.[38] Also in 1975, due to the expansion of the power plants program, the CEA ceased to be the sole owner of nuclear materials in France.

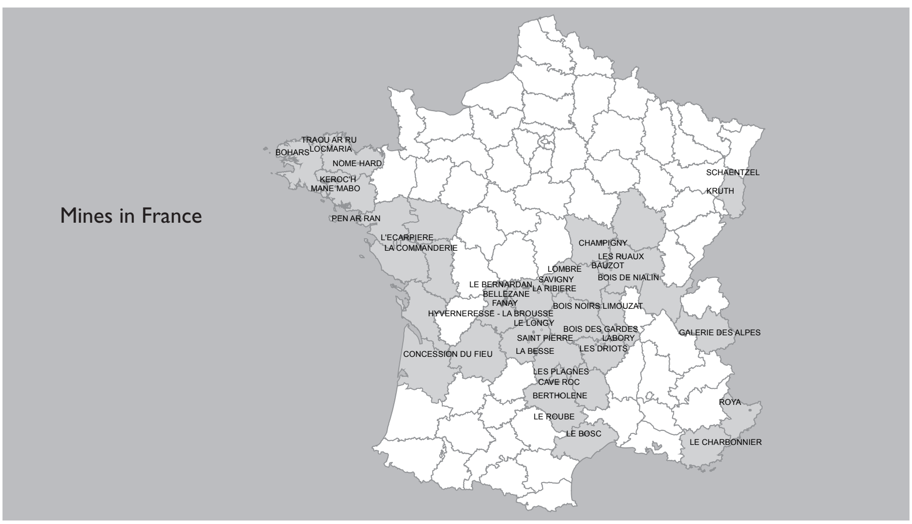
From 1977 to 1981, French exploration activities at home and abroad received 38 million USD of government help.[39] As was the case in other countries, French exploration expenditure and drilling, as well as production capacity, expanded dramatically in 1974 and peaked in the early 1980s before declining back to zero in the early 2000s.[40] Private production represented up to 15% of total domestic production in the 1970s and 1980s.

In 1979, total natural uranium produced and imported by France since the late 1940s was estimated to be 53,690 tons (43,420 tonnes when discounting exports).[41] By 1980, COGEMA had become the first Western producer of uranium, controlling

36 The choice of PWR over BWR was partly driven by the fact that France had experience in operating PWR reactors for its submarines.
37 2,450 tons according to Neff and Jacoby, op. cit., pp. 5-15; 3.000 tons according to Blanc, op. cit., p. 42.
38 Neff and Jacoby, op. cit., pp. 5-11.
39 OECD/IAEA, Forty Years of Uranium Demand, Production and Perspectives, op. cit., p. 46.
40 OECD/IAEA, Forty Years of Uranium Demand, Production and Perspectives, op. cit., p. 46.
41 Neff and Jacoby, op. cit., pp. 5-12.

about 15% of the Western world's reserves.[42] French-led uranium mining industries at that time also included a small number of firms of the IMETAL group (1971), as well as COMINAK in Niger and AMOK in Canada.[43] Australia became another significant supplier after a bilateral agreement was signed in 1981. In 1983, however, Canberra temporarily suspended its sales of uranium to France due to its opposition to French nuclear testing. By 1987, COGEMA was the world's leading producer, extracting nearly 20% of global production (6,117 tonnes).[44]

The 1990s saw France shift decisively to foreign supplies of uranium. In 1989, domestic production peaked at 3,720 tonnes. This allowed France to meet half of its demand for reactors.[45] Domestic mining started to decrease in 1989, foreign mining being more cost-effective. In 1992, production was still 2,149 tonnes, France then being the world's fifth largest producer. In 1993, COGEMA became the sole producer of uranium in France, having bought Total's mining activities as well as CFM. 2001 was the last year of significant uranium production in France (195 tonnes). After the closing of the last mine at Jouac-le-Bernardin (Haute-Vienne) in May 2001, production rapidly fell to 18-20 tonnes in 2002 and 5-6 tonnes in 2011 (from remediation activities at the Herault mines).[46]

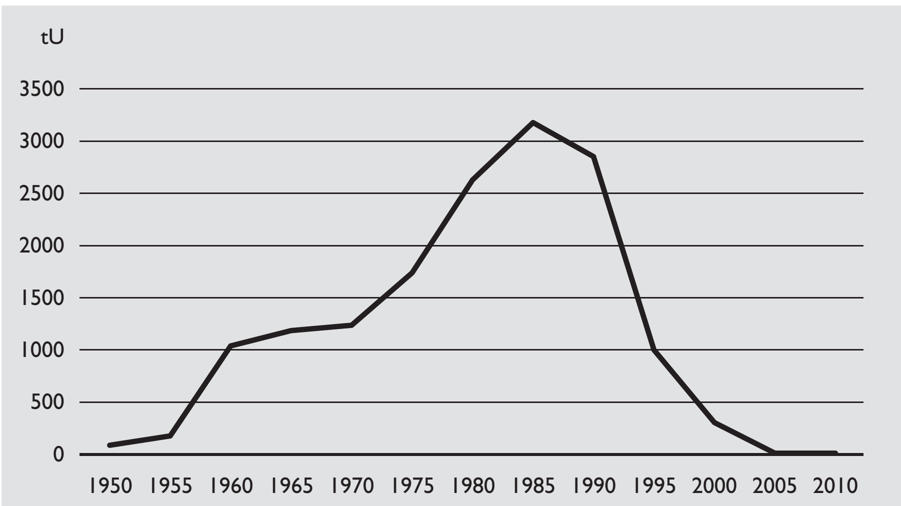


42 Blanc, op. cit., p. 42.
43 Blanc, op. cit., p. 43.
44 Dominique Finon, Uranium in the Shadow of the Worldwide Nuclear Power Crisis: A Market Adjustment Problem, Energy Studies Review, vol. 1, n°1, 30 May 1989, p. 33.
45 Peter Diehl, Uranium Mining in Europe: The Impact on Man and the Environment, WISE, 1995 (electronic version).
46 18 and 5 tonnes according to OECD/IAEA; 20 and 6 tonnes according to the World Nuclear Association.

From 1948 to 2001, France produced on its territory a total of nearly 76,000 tonnes of uranium (out of a total of 52 millions of tonnes of uranium ore). More than one third (26,000 tonnes) was produced in the région Limousin. However, a 2009 re-assessment of French reserves produced new figures of 11,451 tonnes of reasonably assured resources and 139 tonnes inferred, all recoverable at a cost of more than 130 USD per kilo, of which 9,000 tonnes are said to be recoverable by open-pit mining. The exact total of French production by the end of 2010 was 75, 987 to 76,002 tonnes according to the Red Book.

Purification (concentration) processes used in France involved the production of magnesium urinate, ammonium diuranate, sodium uranate or uranyl nitrate. The UF4 produced was converted either to metal (for the early types of reactor) or to UF_6.

FRENCH DOMESTIC URANIUM PRODUCTION 1950-2010[47]



47 Sources: for 1950-1980, Jean Ginier, L'énergie nucléaire en France, L'information géographique, vol. 29, n° 1, 1965; Henri Piatier, La politique nucléaire française, Politique étrangère, vol. 35, n° 2, 1970; Thomas L. Neff and Henry D. Jacoby, The International Uranium Market, MIT Energy Laboratory Report No. MIT-EL 80-014, December 1980, pp. 5-11; and Jacques Blanc, Les mines d'uranium et leurs mineurs français: une belle aventure , Réalités industrielles, août 2008; for 1980-2010, OECD/IAEA ('Red Book'), World Nuclear Association.

France's current status in relation to natural uranium

If we consider the four theoretical categories in which countries could be grouped in relation to the uranium trade – producer states, transit-only states, exporter states or destination states – characterizing France's status with regard to natural uranium appears complex. Two main factors explain why it is difficult to assess France's status.

First, France's historical search to acquire natural uranium flourished and expanded in the 1950s-1960s, and as uranium is abundant in some African countries, this search has been strongly linked to France's history in Africa since the 1950s. This explains why France's pursuit of natural uranium has often been viewed in connection with its policy in relation to its ex-colonies, rather than as an object of research *per se*. The problem with such a perspective is that it mixes up France's policy towards the African states involved and the activities of French state-owned companies in those countries. If agreed strategies do exist between these players, it is important to keep in mind that they have distinct roles and objectives, especially if the subject is about governance, that is, the rules and how players define, enact them and make them evolve. History in significant in understanding the ins and outs of relationships that have been shaped through decades, but it should not obscure other dimensions, such as players' strategies, international relations, and political and economic issues.

The second factor which explains France's complex, if not confusing, status regarding natural uranium is its constant concern for preventing any interference in its military nuclear program.

The military dimension

In order to take into account the role of military concerns in relation to France's consumption of natural uranium, the following paragraphs present the key findings of this paper, as well the specific governance aspects involved.

Uses and quantities

Today in France uranium for military purposes is essentially used for naval propulsion. The French navy operates thirteen LEU-fuelled reactors (six for SSNs, four for SSBNs, two for the aircraft carrier and one land-based test reactor). All of them use low enriched uranium (LEU).

In 1984 (the year the last dedicated plutonium production reactor was shut down), a US expert estimated that France had used 10,000 short tons of natural uranium for military purposes.[48] Given that the French navy at that time operated only a handful of LEU nuclear reactors for SSBNs (and that all French weapons were plutonium-based), it is to be assumed that the vast majority of the natural uranium that had been consumed for military purposes was for the three graphite-gas reactors that the CEA operated from 1956 to 1984 (G1, G2 and G3). These three reactors were mostly – though not only – used for weapons-grade plutonium production.[49] Other users of uranium for military purposes included the two small CEA Célestin reactors, operating from 1967 to 2009, which were devoted to the production of tritium. Another use is depleted uranium munitions.

How much foreign uranium for military purposes is or has been used is unknown. Open-source assessments state that domestic production was sufficient. In 1957, France hesitated between opening a new uranium mine and importing uranium from abroad (see above); if the latter was chosen, Paris was ready to accept safeguards and keep domestic uranium for military purposes.[50] In 1959, a US intelligence report judged that, with 10,000 tons of proven reserves of uranium dioxide, 'France has sufficient uranium ore for its planned program'.[51] In 1967, a key actor in the French nuclear program wrote that domestic production was 'largely sufficient' for its military needs.[52] Still, given that France no longer produces uranium, it has to use foreign uranium for its naval reactors. Government sources refer to a 'very small proportion' of French imports being used to that end. The natural uranium stockpile held by the CEA for military purposes is about 20 tonnes. The annual flux is less than 100 tonnes per year.

International and domestic regulations

During the EURATOM negotiations (1955-1957), France sought to maintain its freedom of action regarding the use of uranium for defense purposes.

The terms of the post-independence agreements between France and several of its former African colonies, including Gabon and Niger, suggested that imported uranium from such countries could be used for military purposes. (The Niger agreement is no longer in force and has been replaced by a 1977 military cooperation agreement that

48 The 1984 study is quoted in Finon, op. cit., p. 40.
49 G1, G2 and G3 also produced a total of 11 billion kW/hours for the French grid. 'Marcoule: les réacteurs plutonigènes G1, G2 et G3 », CEA website, accessed January 2013.
50 Goldschmidt, Le Complexe atomique, op. cit., p. 299.
51 Central Intelligence Agency, The French Nuclear Weapons Program, CIA/SI 47-59, 13 November 1959, p. 4.
52 Goldschmidt, Les Rivalités atomiques, op. cit., p. 278 ; see also Goldschmidt, Le Complexe atomique, op. cit., p. 379.

does not cover natural resources; Gabon does not produce uranium any longer.) Still, one recent source claims that some uranium imported by France is free of use (*libre d'emploi*), that is, there are no restrictions on its use for military purposes.[53] Though it rarely appears in open-source literature, the expression 'free of use' is employed in French government circles, although it does not have any specific legal or administrative meaning.[54] Agreements with producing states reportedly use various ad hoc formulas such as 'non-explosive purposes', etc.

Given that France uses only a small amount of uranium for military purposes, it cannot afford to rely on a dedicated, separated nuclear cycle. Stocks of natural uranium for military purposes are bought by the government either upon importation on the national territory or later in the cycle (after conversion or enrichment).

The control and protection of defence--related nuclear materials was initially organized by a 1981 decree which gave a special status to materials 'for defence purposes or held in nuclear installations of interest to defence.[55] This categorization was changed in 2007, reducing the special status to nuclear materials 'assigned to the means which are necessary to the implementation of deterrence policy'. These include all those which are held in 'nuclear installations of interest to deterrence', or in transit between two such installations, or contained in fuel elements or in weapons. (In practice, this covers essentially nuclear propulsion materials.) By definition, such materials are subject to the special procedures of 'governmental control' instituted to ensure political control over nuclear deterrence assets.[56]

A 2011 decree further refined the regulation of nuclear materials.[57] It organized a set of procedures known as 'materials asset management' (*gestion patrimoniale des matières*) designed to ensure a clear separation of civilian and military 'ownership' of materials, in addition to separate accountings which already existed. From now on, uranium for military purposes will stay safeguarded further along in the process than was the case in the past, 'as late in the process as possible', so to say.

53 Mycle Schneider, Nuclear France Abroad: History, Status and Prospects of French Nuclear Activities in Foreign Countries, May 2009, pp. 21, 24.

54 With the exception of a discreet reference in the nomenclature codes, as shown in this report.

55 Décret n° 81-558 du 15 mai 1981 Relatif au régime de la protection et le contrôle des matières nucléaires dans le domaine de la défense, Journal officiel de la République française, 17 May 1981.

56 Loi n° 2007-289 du 5 mars 2007 portant modifications du code de justice militaire et du code de la défense, Journal officiel de la République française, 6 March 2007.

57 Décret n° 2011-1537 du 16 novembre 2011 relatif à la gestion patrimoniale des matières nucléaires nécessaires à la défense, Journal officiel de la République française, 17 November 2011.

The November 2011 decree institutes the notion of 'mixed' (civilian/military) installations designed to ensure the exact knowledge of the location of any stock earmarked for military purposes. The list of 'mixed' installations is classified, but where necessary details are released by a special body under the supervision of the Prime Minister (the Comité technique EURATOM, created in May 2011) to the European Commission.

The 2011 decree gives the Director of Military Applications of the Atomic Energy Commission a key role. He (1) centralizes information about nuclear materials for military purposes, (2) decides on the quantities of natural uranium (and thorium) which are not subject to EURATOM safeguards, (3) decides on transfers between safeguarded and unsafeguarded activities, (4) notifies such decisions to the industry.

There is no publicly available information about the existence of a strategic stock of natural uranium for military purposes.

A (residual) producer, an importer and an exporter

France has always been, and still is today, a producer of uranium, but this is without any commercial significance, as this production is a side effect of the rehabilitation of old mines. In the same way, France always has been, and still is, a destination state, as well as an exporter state, of natural uranium, both crude and processed.

Static approach: consumption and stocks of natural uranium

Today French nuclear power plants require 1,200 tonnes of fuel (including1,000 tonnes of UO2 fuel, 120 tonnes of MOX fuel and 80 tonnes of URE fuel).[58] Fuel is manufactured by Areva and Westinghouse. This requires about 8,000 tonnes of natural uranium a year. The OECD/IAEA ('Red Book') data mentions 8,000tU for 2009 and 2010.[59] French official data are more specific but vary from one source to another. A 2009 EDF report mentions 8,040tU .[60] Official government data give figures of 7,910tU in 2009 (8,350 including recycled uranium) and 7,205tU in 2010 (7,625 including recycled uranium).[61] Another government agency states 8,400tU .[62] French Parliament mentions 'around' 8,000tU per year, accounting for 200 million euros.[63]

58 Electricité de France (EDF), Le cycle du combustible utilisé dans les centrales EDF, February2012, p. 4.

59 OECD/IAEA, Uranium 2011, op. cit., p. 230.

60 EDF, Rapport pour la réunion du HCTISN du 20 novembre 2009, p. 3.(se note)

61 Ministère de l'écologie, du développement durable, des transports et du logement, Bilans 2009 et 2010 des flux et stocks de matières, 15 September 2011, p. 10.

62 Institut de radioprotection et de sûreté nucléaire (IRSN) website, accessed January 2013.

63 Office parlementaire d'évaluation des choix scientifiques et technologiques, L'avenir de la filière nucléaire en France (rapport final): Rapport de MM. Bruno SIDO, sénateur, et Christian BATAILLE, député, n° 199 tome I, 15 décembre 2011.

About 50 to 75% of this uranium – the proportion varies from year to year – is converted in France at the COMURHEX plant at Malvesi.

One French reactor requires on average 110tU a year, according to AREVA.[64] Specifically, for equilibrium reload are needed 153tU for PWR 900 (107tU if MOX is used) [48 months]; 235-310tU (depending on operation mode) for PWR 1300 [38-54 months]; and 280tU for PWR 1450 [36 months].[65]

EDF has long-term contracts for supplies of natural uranium from Canada, Niger, Kazakhstan and Australia.[66] Taken together, today these four countries represent 80-90% (depending on the year) of natural uranium used in EDF power plants; their hierarchy varies from one year to the other (see tables below for the years 2008, 2009, and 2010). In 2011, EDF reportedly relied for 40% of its uranium on AREVA (half of it from Niger) and for 60% on foreign firms.

In terms of stocks, the latest available data show that stocks reached 27,613tU by the end of 2007, that is to say 27,600tU for electricity generation sector and thirteen tonnes for the research sector.[67] Physically, stocks were located at Malvesi, which serves as a 'warehouse' for most imported natural uranium before the yellowcake is converted, and Tricastin sites, plus small proportions at La Hague, Romans, and at CEA installations. By the end of 2010, stocks were much less, amounting to 15,913tU , 15,900tU for the electricity generation sector and thirteen tonnes for the research sector.[68] They were located at Malvesi and Pierrelatte sites, plus a small part at CEA installations. It is worth noting that, according to the 2006 law,[69] these materials are recorded in accounting terms and physically monitored (it is on the basis of these records that the storage of materials is billed to the converter's customer , who is in most cases the owner of the materials). Physically each drum is individually labeled with the weight of UOC, its nature and its origin. It can happen that a customer of the converter's asks for his own stock to be checked, which is possible as long as the material is not processed.

64 L'uranium, un minerai précieux que l'industrie nucléaire doit économiser, September 2012, Areva website, accessed January 2013.
65 CEA, Mémento sur l'énergie, Edition 2012, p. 45.
66 EDF website, accessed January 2013.
67 Agence nationale pour la gestion des déchets radioactifs (ANDRA), Inventaire national des matières et déchets radioactifs 2009, p. 94.
68 ANDRA, Inventaire national des matières et déchets radioactifs 2012, pp. 46, 50, 87.
69 The 2006 law has created a National Plan for managing radioactive materials and wastes (PNGMDR), updated every three years. It is a public document, elaborated in a concerted way with the different stakeholders involved. The current PNGMDR covers the period 2013-2015.

Dynamic assessment: transfers (imports and exports) of natural uranium

Assessing transfers of natural uranium from and to France requires some methodological remarks. From the viewpoint of this paper, which is to assess the governance of uranium, a geographical division is certainly the most useful. In this respect, we observe that global consolidated figures for imports and exports can easily be found and that determining the geographical breakdown for consolidated export figures is not a problem either.

However, when it comes to sourcing imports, one must be cautious. It is certainly important to differentiate between AREVA's production figures outside France, EDF's consumption broken down by conversion plant origin, imported natural uranium broken down per nuclear facility, and imported natural uranium per country. From that viewpoint, the most relevant source comes from the custom records, available on the custom website,[70] though it does not provide consolidated data. Hence some figures are discrepant with those available in the yearly document issued by the Ministry for Energy's 'Bilan des flux et des stocks de matières', which does not present the breakdown by geographical origin.

If we consider global figures, it appears that from 2006 to 2012:

- Imports have varied from 8,000 to 14,000 tonnes a year (13,947tU in 2011[71], 13,495tU in 2012, according to the customs website).

- Exports have varied from 4,000 to 8,000tU a year (8,384tU in 2011[72]).

Considered from a geographical viewpoint, most natural uranium is imported from ten countries, as shown in the table below, which ranks France's main suppliers in crude and processed - indicated by a (*) - natural uranium:

70 http://lekiosque.finances.gouv.fr/Appchiffre/pays/surcadre_pays.asp

71 This figure is not the same as that (11,016 tons) which agrees with the presentation of the *bilan 2011 des flux et stocks de matières*, made in October 2012 by the Ministère de l'écologie, du développement durable et de l'énergie to the High Committee for Transparency (HCSTIN), available on http://www.hctisn.fr/IMG/pdf/Diaporama_Flux_et_stocks-Presentation_4_oct_2012_cle86e1da.pdf.

72 Source : *Bilan 2011 des flux et stocks de matières*, made in October 2012 by the Ministère de l'écologie, du développement durable et de l'énergie to the High Committee for Transparency (HCSTIN), HCTISN website.

FRANCE'S NATURAL URANIUM IMPORTS (2011-2012)

Countries	2011 (in tonnes)	2012 (in tonnes)
Niger	3375.47	5110.08
Kazakhstan	3289.28	1859.95
Australia	1451.37	1612.83
Uzbekistan	1022.22	1192.2
Namibia	542.76	1010.21
Canada	201.34 (*)	636.34
Ukraine	634.71	0
South Africa	365.64	182.94
Kyrgyzstan	295.89	204.51
Brazil	279.4	129.61
United Kingdom (*)	1167.03	1364.95
USA (*)	0	131.63

(*) Processed uranium. Source: consolidated data from French customs, covering processed natural uranium, as well as compounds and mixtures containing natural uranium (codes 28441010, 28441050).

This table shows that the bulk of France's imports in crude natural uranium are covered by three countries: Niger, Kazakhstan and Australia. Imported natural uranium is mostly ore concentrate (« yellow cake »).

Its two main destinations in France are AREVA's Comurhex plant in Malvési for conversion (75 to 90% of the imports) and to a lesser extent EURODIF Pierrelatte (10 to 25%).[73] This smaller share refers to EDF's imports of processed uranium from other conversion facilities than AREVA's in Malvési, as shown by the breakdown of EDF's consumption of natural uranium according to supplier.

73 Cf. Appendix I. Data on imported uranium split by destination plants for the years 2006 to 2009 can be consulted on Ministère de l'écologie, du développement durable et de l'énergie, Annex to Estimation des importations et exportations de matières nucléaires à partir des données émanant du contrôle national relatif à la protection de ces matières contre tout acte de malveillance, undated document, HCTISN website, accessed January 2013.

FLOW OF NATURAL URANIUM GENERATED BY EDF'S SUPPLY POLICY IN NATURAL URANIUM (2011-2012)[74]

	Rounded values (in tU)	Conversion plants: point of arrival				
		Comurhex (France)	Converdyn (USA)	Cameco (Canada)	Tenex (Russia)	Total
Origin of mineral supplies	**Canada**			1587		**1587**
	Niger	1491				**1491**
	Australie	52	962			**1014**
	Kazakhstan	870	265	197	939	**2271**
	Ouzbekistan	529	0			**529**
	Ukraine	207				**207**
	Namibie	200				**200**
	USA		0			**0**
	Reprocessed uranium (Pierrelatte)					**0**
	Total	**3349**	**1227**	**1784**	**939**	**7299**

As for exports of natural uranium, unsurprisingly they consist mostly of processed uranium. The main destinations are Germany, the Netherlands and Russia.

FRANCE'S NATURAL URANIUM EXPORTS (2011-2012)

Countries	2011 (in tonnes)	2012 (in tonnes)
Germany (*)	2930.23	2426.05
Netherlands (*)	2101.63	1529.88
Russia (*)	1145.21	404.24
United Kingdom (*)	644.18	226.95

(*) Processed uranium
Source: consolidated data from French customs, covering processed natural uranium, as well as compounds and mixtures containing natural uranium (codes 28441010, 28441050).

74 For years 2006-2009, see Appendix II.

II. MAPPING NATURAL URANIUM GOVERNANCE IN FRANCE: THE GRAND RE-ENGINEERING OF THE 2000s

The governance of natural uranium in France is part of the wider governance of nuclear matters, which has been built around two principles: protecting and doing. The history of nuclear was initially about doing and moving forward, the times of 'the pioneers of the atom' (Bertrand Goldschmidt), when nuclear energy develops on a rather weak specific regulatory basis.

In the past twenty years, however, due to growing concerns about non-proliferation, the increasing threat of transnational terrorism and also because of Chernobyl and Fukushima, concerns have shifted more to the side of protection and security. 'The imperative of protection': those are the terms used in the French legislation on nuclear governance (Article R. 1333-1 of the Defence Code), which has been strongly reinforced and redesigned in the last decade.

The 'imperative of protection': a strong reinforcement in the last decade

Nuclear governance in France is framed around the two concepts of security and safety, which are at the heart of this 'imperative of protection'. These concepts are sometimes mixed up or hierarchized in such a way that in many declarations, security seems to encompass both security in its strict sense (protecting nuclear materials from people) and safety (protecting people from nuclear material). For instance, what is defined as nuclear 'security' in 1998 is much more related to what is known today as 'safety': 'Nuclear security is a broad concept which refers to all the measures taken to ensure the protection of people and goods against the dangers, the damage, the inconvenience resulting from the creation, the operation and the shutdown of a nuclear installation, mobile or fixed, as well as from the storing, the transportation, the use and the transformation of radioactive substances, natural or artificial.'[75]

75 Jean-Yves Le Déaut, Le Système français de radioprotection, de contrôle et de sécurité nucléaire: la longue marche vers l'indépendance et la transparence : rapport au Premier ministre, La Documentation française, 1998, p. 134.

To clarify these concepts, we can group the imperative of protection under four different notions:

- Protection of people in case of a nuclear accident.

- Protection against acts of malevolence against nuclear installations or nuclear material transportation, knowing that former mines are not considered nuclear installations under French law (INB).[76]

- Nuclear safety, which consists in 'all the measures taken at the different stages of the conception, the construction, the operation, and the definitive shutdown of nuclear installations in order to prevent accidents or to limit their consequences.'

- Radiation protection, which refers to actions designed to prevent or reduce the harmful effects of ionizing radiation emissions on people and the environment.

Under French law, the first two notions – physical protection – are regarded as being part of the state's general competency in civil security and defence as they are related to nuclear security, while the last two points deal with safety and are governed by different pieces of legislation and specific agencies.

The 2000s or the re-engineering of nuclear governance in France

Historically nuclear activities in France developed on a rather weak legal basis. Surprisingly enough, between 1963 and 2006, there is indeed nearly no legislative basis for safety. One article in a 1961 law on air pollution and a decree issued in 1963 in application of this law, which sets up the notion of 'nuclear basic installation' ('installation nucléaire de base' or INB), defines the principles of prior authorization and of the responsibility of the operator and creates a body of specialized inspectors. The few pieces of legislation were often related to international commitments. For example, as a signatory to the 1979 Convention on the Physical Protection of Nuclear Material, France integrated its principles into French legislation in 1980. But, until this law was passed, the only regulatory framework was an Executive Order issued in 1958 related to the protection of nuclear installations against sabotage.

76 Article 4 from the June 28th 2006 law on Transparency and Wastes states that « Mine waste-storing facilities issuing from former extraction and treatment facilities of uranium ore (...) must be subject to an enhanced surveillance plan, especially for health and environmental concerns. » These facilities are listed in the IRSN data base MIMAUSA (Mémoire et Impact des Mines d'urAniUm : Synthèse et Archives) available on the IRSN website.

This lack of a specific legislative basis should not be interpreted as a sign of poor governance. First, as a member of EURATOM, France followed the rules elaborated at the European level regarding nuclear material. France has also always been a very active and influential member of the IAEA. Furthermore, the very strong role of public law in France, built around the notions of general interest, public service, public interest and public order, has served the development of nuclear governance. 'The unity between public law and nuclear makes the first one naturally adapted to the second', and they have in common the fact that 'decision-makers are the highest state political authorities; the logic behind activities are ones of [administrative] police, prior authorization, policy framework, constraint, surveillance, and control; private legal acts or contracts are left aside to the benefit of unilateral administrative acts which sometimes turn into government acts.'

Nevertheless, as the Minister for Ecology and Sustainable Development noted in the National Assembly during the debates which were to lead to the 2006 law, 'Though France has nothing to envy regarding the best foreign practices in the field of safety and radioprotection (…), our legislation does not live up to our practices and results.' Jean-Yves Le Déaut's report, entitled *The French system of nuclear radioprotection, control and security: a long way to independence and transparency*, published in 1998, can be considered the intellectual and political framework of all the organizational and regulatory changes which took place in the French nuclear system throughout the 2000s.

Five reasons account for these changes.

First, after a period when the CEA, a state body, was the only owner of nuclear material on French soil, the development of nuclear energy in France in the 1970s and its massive industrialization since have resulted in a multiplication of players involved in the nuclear fuel cycle.

The second main evolution occurred following the decisions adopted by the European Union (EU) to introduce more competition into energy markets during the 1990s and to deregulate energy monopolies within the Member States. The French utility which operates the 58-reactor French nuclear fleet, EDF, had been a public body ('*établissement public industriel et commercial*') since 1946. In order to adapt to the new EU regulations, in 2004 it became a company ('*société anonyme*')[77], ruled according to business law. Even though the French state remains a majority stakeholder, with strong power through its role on the Board, part of its capital was privatized. At the turn of the decade, the creation of AREVA represented another sign of the relative *désétatisation* of the French nuclear industry.[78] In 2001, the CEA's industrial shares were collected in a company named AREVA, with an executive board (without any CEA representation) and a supervisory board (where the CEA seats as a majority shareholder). Even though public-owned, these companies acquired much more autonomy, which called for a reinforcement of the regulatory framework in which they operate.

The third major evolution, strongly related to the previous one, has to do with the increased internationalization of French industry, which started at the end of the 1990s with EDF and was reinforced by the creation of AREVA. At the same time, France stopped commercially producing its own uranium, resorting only to foreign sources of supply. Throughout the decade, another evolution took place with EDF's decision to diversify its supply portfolio, thus importing natural uranium to be converted or already converted.[79]

The fourth reason is related to the increasing threat of terrorism since the early 2000s. The adoption of new international agreements and threat analyses in France have both led to a reinforcement of the national regulatory framework, in parallel with the international reinforcement in 2005 of the Convention on the Physical Protection of Nuclear Material.

Last but not least, it was about time that, in line with IAEA's general safety requirements[80] France separated promotional and control activities in the nuclear sector and set up an independent safety authority.

77 EDF is a « société anonyme à capitaux publics ». Leaving the status of an EPIC enabled EDF to diversify its commercial activities, which was previously forbidden, as an EPIC's missions are limited to fulfilling the public service.

78 Legally, though, one should bear in mind that the creation of AREVA in 2001 meant 'only' that the CEA turned from being a financial holding to an industry holding vis-à-vis the three industrial groups whose shares it owned (COGEMA, Framatome et Technicatome) within an entity called CEA-Industrie, created in 1983.

79 Cf. Annex II.

80 IAEA Safety Standards, General Safety Requirements Part 1, Governmental, Legal and Regulatory Framework for Safety, http://www-pub.iaea.org/MTCD/publications/PDF/Pub1465_web.pdf.

In this respect, it is no exaggeration to state that, if safety culture and practices were very strong prior to 2006, the French governance system for nuclear activities has been considerably reinforced by, and in the wake of, the 2006 law on nuclear transparency and security (referred to as the TSN law). Besides this law, which, among many other provisions, set up a truly independent safety authority, huge regulatory changes were introduced between 2005 and 2011 regarding nuclear materials and their protection:

- A first stage was the codification of the regulation on the protection of nuclear material against acts of malevolence in the Defence Code in 2005. The rules to be followed are defined in the Defence Code in its Articles L. 1333-1 to L. 1333-14 and are structured around three key words: authorization, control, and sanctions.

- An Executive Order (*ordonnance*) issued in 2006 clarified the regime of nuclear materials dedicated for 'defensive' purposes: while the previous regime distinguished between the 'defensive' purposes of nuclear materials and others, the new law makes a distinction between 'materials dedicated to the [nuclear] deterrent' and others. In practice, this meant narrowing the derogatory regime linked to France's status as nuclear-weapons state.

- Décret n° 2007-830 du 11 mai 2007 on the classification of nuclear base installations (INB), which states that installations involving radioactive substances in the form of uranium ore, residuals, or products issuing from the treatment of the ore are not INB. Malvesi, where most of the imported natural uranium is stored, is therefore not an INB but an 'Installation Classified for the Protection of the Environment' under prefect authorization ('SEVESO' infrastructure). In 2009, ASN requested that part of the Malvési plant should be classified as an INB, but this request was related not to the part of the plant where natural uranium is processed, but to the effluent treatment basins. The re-classification process is still pending.

- The next step was taken in 2009 with a decree on the protection and control of nuclear material, their installations and transportation.

- This regulatory round ended in 2010 and 2011 with the publication of ten implementing regulations (*arrêtés d'application*) of this decree, related to the declaration regime, the modalities and content of the form of authorization, the physical protection of installations, the physical follow-up of nuclear material, and the accountancy of nuclear material.

Ten years of an intense legislative process have put security at the heart of the French governance of nuclear material in general and of natural uranium specifically. The governance of uranium in France today forms a complex regulatory system, built upon three intertwined sources of law: international treaties and commitments, the European level, and French regulation.

The emergence of independent institutions for protection

This intensive regulatory wave in the nuclear sector has seen the emergence of two major new players: the creation of the Institute for Radioprotection and Nuclear Safety (IRSN) in 2001 and the emergence of the Nuclear Safety Authority (ASN) in 2006. Formerly parts of ministerial departments, ASN and IRSN are today the masterpieces of the French system nuclear material public governance as far as safety and radioprotection are concerned. Their creation helped clarify the notions of nuclear safety on the one hand and nuclear security on the other hand.

Created in 1973, what is known today as ASN was an administrative service reporting to the Minister in charge of the industry, the Central Service for the Safety of Nuclear Installations (Service Central de Sûreté des Installations Nucléaires). This became the Direction de la Sûreté des Installations Nucléaires in 1991 and was, as of 2002, accountable to both the Ministry for Industry and the Ministry for the Environment. Law 2006-686 of 13 June 2006 concerning nuclear transparency and safety (known as the 'TSN law') finally institutionalized the Nuclear Safety Authority (ASN) as an independent administrative authority, separating the activities of promotion and of control of nuclear. The new institution is tasked, on behalf of the State, with regulating nuclear safety and radiation protection in order to protect workers, patients, the public and the environment from the risks involved in nuclear activities. It also contributes to informing the citizens.

ASN key figures

- More than 450 staff, nearly half in the eleven regional divisions.
- 276 inspectors distributed among the regional divisions and the departments
- 81% management level.
- A total budget of 142 million euros, including 76.5 million devoted to assessments.
- More than 870 inspections per year of nuclear installations and radioactive material transport.
- Nearly 1220 inspections per year in the medical, industrial and research sectors.
- More than 10,445 inspection follow-up letters published on the website www.asn.fr

IRSN, a public authority with industrial and commercial activities, was set up by Article 5 of French Act No. 2001-398 of May 9, 2001, and enacted through Order No. 2002-254 of February 22, 2002. This Order was amended on April 7, 2007. The Institute is placed under the joint authority of the Ministries of Defence, the Environment, Industry, Research and Health.

The nation's activities and public service expertise in nuclear and radiation risks cover all the related scientific and technical issues. Its areas of specialization include the environment and radiological emergency response, human radiation protection in both a medical and professional capacity and in both normal and post-accident situations, the prevention of major accidents, nuclear reactor safety and safety in plants and laboratories, transport and waste treatment, and nuclear defence expertise. IRSN interacts with all parties concerned by these risks (public authorities, in particular nuclear safety and security authorities, local authorities, companies, research organizations, stakeholders' associations, etc.) to contribute to public policy issues relating to nuclear safety, human and environmental protection against ionizing radiation, and the protection of nuclear materials, facilities and transport against the risk of malicious acts.

These agencies interact with the following public authorities involved in nuclear governance:

- The Ministry of Foreign and European affairs, in charge of following up the implementation of agreements signed by France and of promoting France's actions regarding non-proliferation, arms control and disarmament.

- The Ministry of Ecology, Sustainable Development and Energy, which is part of the definition of France's energy and nuclear policy.

- The Ministry of Defence, which plays a role in controlling nuclear materials and the elaboration of France's non-proliferation policy.

- The Prime Minister's services (Comité Technique EURATOM).

- The Atomic Energy and Alternative Energies Committee (Commissariat à l'énergie atomique et aux énergies or CEA[81]) for those aspects of its work that have to do with sovereignty (its international Director is the governor for France at IAEA).

Moving forward: nuclear industry and its stakeholders

Historically the organization and governance of the nuclear sector in France have been shaped around the imperative of action, which was to serve France's defence and industrial needs. Nowadays, this imperative is embodied in a strong nuclear industry. It has to deal with stakeholders, the role of which has been institutionalized by the law.

The complex institutional interaction between the industrial players

The creation of the CEA as early as October 1945, in a country ruined by the war, was symptomatic of this determination to act and move forward on nuclear. The CEA enjoyed an *ad hoc* status which gave it huge room for maneuver. Although its status has been 'normalized' since (it is now an 'établissement public industriel et commercial'), the CEA still has a dual role, with very strong research activities (not only in nuclear), but also, as explained previously, with an industrial role as a major shareholder of AREVA and with sovereignty-related activities. In this respect, the CEA is typical of this constant tension within the French nuclear world, being both the 'war machine of the atomic state'[82] and an important nuclear shareholder, even if a less and less important one.

A quick glance at EDF and AREVA shareholder breakdown may lead one to think that, whatever the legal form (both are '*sociétés anonymes*'), nothing has really changed given the overwhelming weight of the State and the CEA.

81 The CEA indeed also conducts research on renewables. Beyond energy, the CEA has defense activities, related to the French deterrent, as well as activities in the field of nanotechnologies or biotechnologies.

82 Olivier Guézou and Stéphane Manson (eds.), Droit public et nucléaire, Bruylant, Bruxelles, 2013, p. 53.

EDF BREAKDOWN OF SHARE CAPITAL AND VOTING RIGHTS

At 31 December 2011, voting rights were split as follows:

	Number of Shares	% Shares	% Voting rights
French State	1,561,222,705	84.40	84.50
Public (institutions & retail investors)	252,420,651	13.65	13.66
Employee shareholding	34,047,712	1.84	1.84
Treasury shares	1,175,594	0.07	-
Total	**1,848,866,662**	**100.00**	**100.00**

Source: EDF web site.

AREVA BREAKDOWN SHARE CAPITAL AND VOTING RIGHTS

	Sept. 20 2013	Dec. 31 2012	Dec. 31 2011	December 31 2010	
Shareholder	% of capital and voting rights	% of capital and voting rights	% of capital and voting rights	% capital	% voting rights
CEA	61.52	73.03	73.03	73.03	77.15
French State	21.68	10.17	10.17	10.20	10.23
Kuwait Investment Authority (KIA)	4.82	4.82	4.82	4.83	4.84
BPI-Groupe	3.32	3.32	3.32	3.33	3.33
EDF Group	2.24	2.24	2.24	2.24	2.25
Framépargne (employees)	0.24	0.26	0.26	0.35	0.36
Crédit Agricole Corporate and Investment Bank (CA CIB)	-	0.89	0.89	0.89	0.89
Total Group	0.95	0.95	0.95	0.95	0.95
Public	4.02	4.01	4.01	3.74	-
Members of Supervisory Board	ns	ns	ns	ns	ns
Employees	1.01				
AREVA	0.21	0.31	0.31	0.22	-
Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Source: AREVA web site.

It would be misleading, though, to conclude from this shareholding breakdown that the French state, EDF and AREVA are only different faces of the same body. 'France Nuclear Inc.' does not exist. Indeed, when talking about the importation, consumption, production and export of natural uranium, it is important to bear in mind that, even if French industrial players in this sector are state-controlled companies, confusion should be avoided between France as a country and these companies, which, like any company, follow and implement a strategy under a governance regime defined by their status.

The French state is at the same time a majority stakeholder for EDF or AREVA, a regulator and a negotiator when acting as a diplomatic power. These different roles, embodied in different structures within the state, can lead to some inconsistency: commercial and industrial objectives are key, but the promotion of the highest safety standards, non-proliferation policy and anti-terrorism also stand at the highest level on the political agenda. This tension has always existed, but it was less visible at the time when all these institutions – CEA, ASN, EDF – were different tools for the French state to move forward on nuclear affairs. It will therefore be one of the challenges of this paper to assess whether intertwining structures, roles and responsibilities weaken the uranium governance system, or just make it more difficult to describe and understand, without any effect on its efficiency.

What is more, the two companies are very different from one another, mainly for historical reasons: EDF's culture is that of a powerful monopoly that is something of a newcomer in international markets; AREVA is much smaller and much younger, and is backed by the powerful CEA. These strong historical, cultural and sociological differences explain why categorizing them as 'state-owned' or 'public-controlled' companies, as if they were only the commercial 'armed wing' of the French state, is at least deceptive, if not wrong.

Not only are they very different from one another, but each of them also has to manage diverging trends within its own structure. In understanding nuclear governance in France, these internal tensions are important. AREVA, for example, is made up of different cultures: the attitudes of those who work in its mining activities are very different from those that prevail in the back-end sector. While the former are 'field' people, with an enduring spirit of adventure and discovery, back-end people have developed a public-oriented culture and are more used to handling sovereignty and security issues. It is they who are in charge of highly radioactive materials and waste, working very closely with the state, both in France and abroad. If we add enrichment activities to this landscape , the culture is also different, with a mixture of a strongly commercial approach, related to the strong competition in the enrichment market, and of high levels of security concerns given the sensitivity of enrichment. The difference is also strong with the technical rough culture of the '*métallos*' (engineers and technicians) from the former Framatome.

The major changes we described earlier within the industry sector are recent: hence the fierce debates displayed in public between EDF and AREVA, not to mention the less public ones involving the CEA, which are so symptomatic of the difficulty for this new system to find the right balance between protection and action. It is no surprise that the government-commissioned Roussely Report on the future of the French nuclear power sector, published in 2010, advocated the reinforcement of the governance of nuclear 'to ensure the efficient control of the sector's many strategic, political and industrial challenges.' In parallel, it recommended that AREVA's mining activities should be conducted by a subsidiary of AREVA instead of being a mere business group. It considered that, with new (minority) shareholders, who could be AREVA's customers, the development (financing) of mining activities could be ensured.[83]

The complex intertwined relationships between the 'big ones' in the French nuclear sector and their titanic battles should not lead us to forget that the sector represents 2,500 companies, with a total of 220,000 workers, and EUR46 billion in revenues. Mostly private companies, they all participate in the global governance of nuclear energy.

The institutionalization of transparency: the increasing role of stakeholders

The TSN law introduced a major institutional change in the nuclear landscape in France by putting the principle of transparency at the heart of its governance. Civil society has become by the law, a full part, of nuclear governance in France. Civil society has been legally represented since 2006 through two organisms: the local commissions for information (*commissions locales d'information* or CLI) and the High Committee for Transparency and Information on Nuclear Security (HCTISN).

One could consider that, along with governmental and public bodies, they are more interested in the protection side as, even though CLIS can order expertise and

83 This recommendation has been followed up with the creation of AREVA Mines, which is now a subsidiary of AREVA.

technical analyses, it is funded by the industry and the ASN, their role basically to make information available. In our view, though, even though they are observers rather than players in the sector, their role as a constant stimulus for the industry justifies categorizing them in this section, not to mention the fact that the only major improvement in a sector with a long-lasting tradition of secrecy has been to make information available.

In this respect, we do not share certain negative viewpoints, for example, that 'it's [the HCTISN's] activity in terms of reporting and opinion does not seem to promote strong transparency in nuclear-related information'[84]. CLIs and HCTISN are certainly new institutions and are struggling to find a proper place in the French nuclear landscape. Nevertheless, when carrying out this research on uranium, we have experienced the usefulness of the pieces of information they provide, which would never have been accessible a few years ago. For example, the work done by HCTISN in 2009 on the occasion of a public controversy regarding uranium flows from and to Russia is to be considered a major improvement and has really enabled civil society to access documents which had previously never been published. A TV program broadcast on ARTE in October 2009 indeed mentions that some of the enriched uranium used on French territory came from TENEX in the framework of an enrichment contract. A whole debate took place about the fuel cycle (enriched, depleted and reprocessed uranium), with a public hearing organized in Parliament by the Parliamentary Office for Technological and Scientific Choices (OPECST), which also took the matter to the HCTISN.

84 Olivier Guézou and Stéphane Manson (dir.), op. cit., p. 173.

III. REGULATING NATURAL URANIUM: SECURITY AS THE CORNERSTONE OF NATURAL URANIUM GOVERNANCE

Security is the cornerstone of the governance of natural uranium in France. It is around this pivotal notion that the whole system is organized, in its purely domestic dimension, as well as in its interaction with foreign countries. There is indeed no discontinuity between the international and the domestic levels, certainly because the quest for natural uranium has always had an international dimension in France. This is all the more true now that France depends exclusively on imports for its uranium supply.

The role of security as the guideline for France's governance of natural uranium both within and outside its borders has always been mentioned by French officials. On the occasion of a debate raised in 2009 on the exchange of nuclear materials with Russia, the French state, through the Ministry in charge – the Ministry for Ecology, Sustainable Development and Energy – again recalled the French vision about natural uranium supply and exports. After stating that 'France thus depended exclusively on other countries for its international supply', the Director for Energy and Climate asserted that 'this dependency was not a problem because: 1) supplies are diversified, France depended on a dozen or so different countries, which enabled competition; 2) the countries from which uranium is imported are globally secure.' He nevertheless warned that France had to 'remain vigilant in the breakdown of the various areas in the world endowed with natural uranium in France's supply portfolio so that it should not be made dependent on one specific country'. He then mentioned that the 'strategy of diversification in natural uranium supply is also applied at the stages of conversion, enrichment and fuel manufacture'. Therefore, resorting to foreign facilities has nothing to do with any shortcomings or deficiency on the part of France, which is 'one of the few countries able to master all the stages of the fuel cycle', but represents another aspect of the policy of diversification, should any industrial facility encounter problems.

Uranium governance is seen as a security issue in both meanings of the word: protecting nuclear materials from potential physical threat, but also ensuring France's security of supply: *'this strategy of securing supply can only be implemented if the state is vigilant on the treatment of nuclear substances sent abroad, as well as on the movements of nuclear substances to or from France. National and international regulation enables control of these movements.'*

The whole system is indeed organized so as to deal with three major concerns:

- Ensuring security of supply.
- Preventing the theft or diversion of materials (physical security and protection), especially during the transportation.
- Fighting proliferation.

Ensuring security of supply: France's uranium foreign policy

To further strengthen its security of supply, France has organized its nuclear cooperation within the framework of bilateral agreements, some of them with countries which are already covered by a EURATOM agreement (Australia, Japan, etc.).[85] Any trade related to uranium is at least formalized by an exchange of letters.

Assessing the number of bilateral agreements signed by France in the field of nuclear cooperation is not so easy. It depends on whether one includes only intergovernmental agreements or also those signed by public bodies such as the CEA, and also on the extent of the cooperation involved.[86]

The most extensive review of these agreements was made in 2009 in James Keeley's list of nuclear cooperation agreements, which goes back to the 1960s.[87] If we add the few that have been signed by the French state since 2009, we reach a total of 356 agreements, expired, in force or with an unknown status, signed with 62 countries (one being with the EU). The list includes intergovernmental ones, as well as exchanges of letters and agreements signed by other institutional actors than ministries – the CEA especially, but also IRSN, etc.

85 In accordance with the treaty establishing a European Atomic Energy Community (EAEC), cooperation agreements have been concluded between the EC, mandated by the Member States, and third-party states. France therefore implements the following treaties: EURATOM/USA (1996), EURATOM/Canada (1959), EURATOM/Australia (1982), EURATOM/Japan (2007), EURATOM/Ukraine (2006), EURATOM/Uzbekistan (2003), EURATOM/Kazakhstan (2009).

86 On the website of the Ministry for Ecology, Sustainable Development and Energy, eighteen countries are mentioned with which a cooperation agreement is currently into force: South Africa, Algeria, Brazil, Bulgaria, China, Egypt, United Arab Emirates, Hungary, India, Italy, Jordan, Libya, Lithuania, Poland, Czech Republic, Russia, Slovakia and Tunisia. The IRSN 2011 Activity Report mentions that to date, 24 bilateral agreements for cooperation in the development of the peaceful use of nuclear energy have been signed with third countries (op. cit., p. 63).

87 James F. Keeley, A List of bilateral civilian nuclear co-operation agreements, vol. 2: Afghanistan-German Democratic Republic, University of Calgary, pp. 162-205, 2009. We owe a special thanks to Jaclyn Tandler for drawing our attention to this table, and for the tremendous work she has done in updating its data.

The following table lists only those countries with which an *ad hoc* nuclear cooperation agreement has been signed, as well as the uranium-related agreements. It summarizes[88] the 43-page review drawn up in 2009 and has been updated with more recent intergovernmental agreements and completed with what we have identified as missing agreements such as that with Gabon, for example. The table is not claimed to be exhaustive, as some agreements, especially exchanges of letters, may not have been made public.

FRANCE'S PAST AND CURRENT NUCLEAR COOPERATION AGREEMENTS

Countries (number of expired agreements/in force or with unknown termination)	Expired agreements explicitly mentioning uranium cooperation (date of signature of termination)	Intergovernmental general cooperation agreements mentioning nuclear, intergovernmental nuclear cooperation agreements, specific uranium agreements with unknown/unspecified duration termination date/with a provision for periodical review (date of signature)
Algeria (2/3)		Agreement on the Use and Development of Nuclear Energy for Peaceful Purposes (2007); includes fundamental research, technology transfer, training, electricity production, and prospecting for and exploitation of uranium.
Argentina (1/9)		Co-operation in the Exclusively Peaceful Use and Non-Explosive Use of Nuclear Energy (1994)
Australia (2/5)		Nuclear transfers (1980, 1981)
Bolivia (0/1)		CEA exchange of Letters on mineral prospection (1971)
Brazil (1/5)	Cooperation in the peaceful uses of atomic energy (1962-1974)	Scientific and technical cooperation (1968)
		Uranium plant contract (1976)
		Scientific and Technical Cooperation in the Field of the Peaceful Uses of Nuclear Energy (2002)
Canada (1/4)		Exchange of Letters concerning the Canada–EURATOM agreement on the Peaceful Uses of Nuclear Energy (1981).
Central African Republic (0/2)		Uranium Mining Agreement (1967)
		Creation of uranium mining company (1968)
China (3/13)		
		Scientific and technical cooperation (1978)
		Cooperation for the Utilization of Nuclear Energy for Peaceful Purposes (1997)
		Implementation agreement for the 1997 agreement (2007)

88 The full version of the table can be found in Appendix I, with all the signed agreements.

Countries (number of expired agreements/in force or with unknown termination)	Expired agreements explicitly mentioning uranium cooperation (date of signature of termination)	Intergovernmental general cooperation agreements mentioning nuclear, intergovernmental nuclear cooperation agreements, specific uranium agreements with unknown/unspecified duration termination date/with a provision for periodical review (date of signature)
Egypt (1/3)		Peaceful uses of Nuclear Energy (1981)
Gabon (0/1)		Cooperation agreement on raw materials and strategic products (1960)
Hungary (1/3)		Scientific and technical cooperation (1983)
India (2/19)	Peaceful uses of Nuclear Energy (1965-1975)	Peaceful uses of Nuclear Energy (2008)
		Confidentiality of technical data (2010)
Indonesia (2/3)	Peaceful uses of Nuclear Energy (1969-1979)	
	Geology and Mineral exploration (1979-1982)	
Iran (1/3)	Nuclear cooperation (1974-1984)	Uranium prospection and exploitation (1961)
		Uranium prospection and exploitation (1969)
Iraq (1/1)	Peaceful uses of Nuclear Energy (1975-2001)	
Israel (0/3)		Cooperation on uranium phosphate (1954)
Italy (1/10)		University, scientific and technical cooperation on nuclear energy (2010)
Japan (4/26)		Peaceful uses of Nuclear Energy (1972)
Jordan (0/1)		Peaceful uses of Nuclear Energy (2008) – refers to uranium exploration and exploitation
Kazakhstan (0/2)		Friendship and cooperation (1992)
		Peaceful uses of Nuclear Energy (2011)
Korea (1/9)		Peaceful uses of Nuclear Energy (1974, 1981, 1985)
Libya (0/6)		Peaceful uses of Nuclear Energy (2007) – refers to uranium exploration and exploitation
Mexico (0/4)		Peaceful uses of Nuclear Energy (1979) – refers to uranium exploration and exploitation
		CEA agreement on prospection and exploitation of uranium (1980)
		Economic cooperation (1981)
Morocco		Preliminary accord on nuclear cooperation (discussions in 2007, signed?)
Niger (0/3)		Agreement (1960). 'Note: WMDI reports that this agreement gave French companies a de facto monopoly over Niger's uranium'

Countries (number of expired agreements/in force or with unknown termination)	Expired agreements explicitly mentioning uranium cooperation (date of signature of termination)	Intergovernmental general cooperation agreements mentioning nuclear, intergovernmental nuclear cooperation agreements, specific uranium agreements with unknown/unspecified duration termination date/with a provision for periodical review (date of signature)
		Exchange of letters concerning the mining discovered by CEA plus protocol specifying mining conditions (1967)
Pakistan (0/4)		Nuclear cooperation (1976, 1991)
Philippines (0/1)		Peaceful uses of Nuclear Energy (1976)
Qatar (0/2)		Economic and financial cooperation (1974)
		Nuclear cooperation agreement (2008)
Russia (7/17)	Peaceful uses of Nuclear Energy (1965-1967)	Peaceful uses of Nuclear Energy (1960)
		Scientific and technical cooperation (1966)
		Peaceful uses of Nuclear Energy (1967)
		Delivery of enriched uranium to France (1971)
		Scientific and technical cooperation (1990)
		Civilian nuclear security (1992)
		Peaceful uses of Nuclear Energy (1996)
Saudi Arabia (0/1)		Economic cooperation (1975). NB: unclear whether this came into force.
South Africa (0/3)		CEA agreement on long-term supply of natural uranium (1964)
Sri Lanka (0/2)		Peaceful uses of Nuclear Energy (1980)
Sweden (0/4)		Joint studies in the field of uranium metallurgy (1951)
		Atomic fuel (1969)
Switzerland (5/8)	Peaceful uses of Nuclear Energy (1957-1968; 1970-1990)	Peaceful uses of Nuclear Energy (1990)
Tunisia (0/2)		Civilian nuclear cooperation (2008), including uranium prospecting
Turkey (0/2)		Nuclear cooperation agreement (1999)
Ukraine (0/2)		Peaceful uses of Nuclear Energy (1998, to be terminated in 2020)
United Arab Emirates (0/2)		Cooperation (1980) and framework agreement (2008)
United Kingdom (1/9)		Supply of uranium slightly enriched (1955,1965)
		Nuclear cooperation (2008)
United States (24/19)	Civil uses of Nuclear Energy (1956-1966)	Uranium studies (CEA, 1960)
Uruguay 1		Peaceful uses of Nuclear Energy (exchange of letters, 1970)
Vietnam (0/2)		Peaceful uses of Nuclear Energy (1996, 2004)

This table calls for the following remarks:

- The diplomatic instruments used for nuclear cooperation are extremely diverse. Specific conditions can be set up, especially about the end-use of materials and IEAE controls. Even if never said as such, they are assessed regarding the legal situation of the country vis-à-vis IAEA requirements and according to the country's track-record in the field of non-proliferation.

- Most of them have to do with research, far fewer with actual commercial relationships.

- The recent increase in the number of nuclear agreements reflects the 'nuclear diplomacy' of President Nicolas Sarkozy.

- This renewed nuclear diplomacy targets technologies (reactor sales) much more than resources. This is not surprising, as the golden age of the 'all directions' quest for uranium has given way to the benefit of a strategy focused on just a few countries, with Kazakhstan appearing as the new major supplier, in addition to the traditional role of Niger. This is mainly due to the fact that nowadays the discovery of new deposits is the result of 'technico-scientific research based on the costly implementation of geophysics and geochemistry methods.'[89] When gigantic mines are found as in Kazakhstan or Canada (at Cigar Lake), new prospection is discouraged.

- It is not surprising that nuclear relationships with African countries are framed by uranium, with the exception of South Africa, which is primarily seen as a market for selling technologies (reactors). It is interesting to note that the diplomatic basis for these relationships is rather weak.

As for *Namibia*, for example, there is currently no bilateral agreement: due to the postponing of the operations in Namibia by AREVA, installations have been mothballed. France therefore considers that no such agreement is currently required.

With *Niger*, France's major long-term supplier of natural uranium, the table above refers to an agreement made right after the decolonization (1961), which we have not seen. Is it still in force? The 1977 military cooperation agreement does not cover natural resources. As said previously, Nigerien natural uranium imported to France is said 'free of use'. This means it belongs to category 'N', which, in the EURATOM

89 Henri Métivier, op. cit., p. 23.

obligation codes, refers to 'materials not submitted to a EURATOM or an IAEA commitment'. As shown in the table (cf. p. 50) describing the corresponding codes between the EURATOM and French nomenclature, the two letters 'LE' mentioned in the last column '*futurs codes nationaux*' ('future national codes') mean '*libre d'emploi*', that is to say 'free of use'. This weak diplomatic base raises the issue of whether the same practice of free use would be sustainable with the development of the triangular relationship between France, Niger, and China. As stated in the 2007 agreement between China and France (Article 6), 'both parties encourage French and Chinese industry to develop their cooperation in the research and exploitation of natural uranium resources in third countries, outside of the signing EURATOM countries, based on respect for each other's interests.'[90] The question may be raised regarding China's extraction of natural uranium from Nigerien mines in the framework of the cooperation between AREVA and the Chinese.

The agreement on raw material and strategic products signed in 1960 with *Gabon*, which is still into force according to the PACTE database[91] (the official Ministry of Foreign Affairs records), where international agreements signed by France are to be found, may nevertheless give a good hint of the one signed with Niger. It covers not only uranium but also 'thorium, beryllium or lithium and helium' (Article 1[92]), as well as hydrocarbons. According to Article 5, 'the French Republic is informed about the program and projects regarding exportations outside of the territory of the Gabonese Republic of raw material and strategic products of the second category mentioned in Article 1,'[93] which refers to uranium, thorium, beryllium, lithium and helium. The same article also specifies that Gabon must give priority to the Community – i.e. France and its other former colonies – when selling these materials. We have found no information about its current status.

90 Accord d'application de l'accord de coopération du 15 mai 1997 entre le Gouvernement de la République française et le Gouvernement de la République populaire de Chine pour le développement des utilisations pacifiques de l'énergie nucléaire, 26 novembre 2007, http://basedoc.diplomatie.gouv.fr/Traites/Accords_Traites.php.

91 As mentioned previously, Gabon is no longer a uranium exporter.

92 Accord de coopération pour les matières premières et les produits stratégiques conclu entre la France et le Gabon le 17 août 1960 publié in décret n°60-1231 du 23 novembre 1960 portant publication des accords particuliers conclus le 17 août 1960 entre le Gouvernement de la République française d'autre part, le Gouvernement de la République gabonaise d'autre part, Journal officiel.

93 *Ibid*.

Preventing the theft or diversion of materials

A centralized system

Implementation of the controls on nuclear material is the concern of a specialized authority, set up in 1981 under the authority of the High Civil Servant for Defense (Haut-Fonctionnaire de Défense or HFDS), who reports to the Minister for Energy. The HFDS oversees a small administration, the Service for the Security of Economic and Nuclear Infrastructures (Service de Sécurité des Infrastructures Economiques et Nucléaires). It has correspondents in the companies dealing with nuclear material, which are by law compelled to have a security officer.

The HFDS is in charge of delivering the general authorization for handling nuclear material, their follow up and accountancy. In practice, IRSN keeps the accounts and instructs the files. The HFDS is also responsible for issuing transport authorizations. Authorization is indeed the general rule except for small amounts of material. As shown by the table below, any activities of the transfer, holding, use, transport, import or export of natural uranium above 500 kg are subject to a prior authorization; a declaration only is needed below 500 kg.

HFDS activities are technically supported by the service of Defence Nuclear Expertise at IRSN, which actually conducts on-site inspections, investigates the files for nuclear material transportation, and keeps the centralized account of nuclear materials.

In practice, for natural uranium, these controls can be made at the port where materials are unloaded or at the facilities where it is stocked. For example, if uranium is stockpiled at Malvési, AREVA is responsible for ensuring the security of uranium even if the contractor, which in France is mostly the utility (uranium end-user), is the owner of the material, linked to AREVA through a conversion service. It is worth noting that, when contracts involve brokers, intermediaries or banks, this does not imply physical movement of the material but only book transfers on quantities located at conversion plants.

Transporting uranium: implementing governance beyond national borders

Transportation is vital for the nuclear industry: as there are very few conversion plants in the world,[94] uranium needs to be transported long distances. In terms of record, it is only fair to acknowledge that to date, no accident beyond level 1 on the

94 There are nine located in Brazil, Canada, China, France, Iran, Russia, United Kingdom and the USA (source: http://www.wise-uranium.org/efac.html).

	Authorization				Declaration	Exemption
	Category I	Category II	Category III			
Plutonium (Tous isotopes)	Pu > 2 kg	2 kg > Pu > 400 g	400 g > Pu > 3 g	N/A	3 g > Pu > 1 g	1 g > Pu
Uranium (U235 > 20 %)	U235 > 5 kg	5 kg > U235 > 1 kg	1 kg > U235 > 15 g	N/A	15 g > U235 > 1 g	1 g > U235
Uranium (20 % > U235 > 10 %)	N/A	U235 > 5 kg	5 kg > U235 > 1 kg	1 kg U235 > 250 kg	250 g > U235 > 1 g	1 g > U235
Uranium (10 % > U235)	N/A	N/A	U235 > 5 kg	5 kg > U235 > 250 g	250 g > U235 > 1 g	1 g > U235
Natural Uranium **Depleted uranium** **Thorium**	N/A	N/A	U235 > 500 kg Th > 500 kg	N/A	500 kg > U235 > 1 kg 500 kg > Th > 1 kg	1 kg > U235 1 kg > Th
Uranium 233	U233 > 2 kg	2 kg > U233 > 400 g	400 g > U233 > 3 g	N/A	3 g > U233 > 1 g	1 g > U233
Deuterium	D > 200 kg				200 kg > D > 1 kg	1kg > D
Tritium	H3 > 5 g	5 g > H3 > 2 g	N/A	N/A	2 g > H3 > 0,01 g	0,01 g > H3
Lithium	N/A	N/A	Li6 > 1 kg	N/A	1 kg > Li6 > 1 g	1 g > Li6
Irradiated Fuel	N/A	A ll fuels	N/A	N/A	N/A	N/A

International Nuclear Event Scale (INES) scale has ever been reported for nuclear material transportation. Let us recall that of the 20 million[95] transports of radioactive material that take place in the world each year, 95%[96] are not fuel-cycle related and that in the case of the remaining 5%, spent fuel transports are by far the most dangerous. Compared to this kind of transport, those involving natural uranium present a relatively low degree of risk. The standardized chemical form of natural uranium used for transportation on long distances is U3O8 – the yellow cake. Even if less than 1% of this material is made of uranium 235, which means it is a 'low-activity material which does not pose an important radiological risk';[97] uranium transportation obeys the international rules related to nuclear material transportation in respect of both containment and control.

This paper is concerned with the rules applied in France, but it will necessarily focus on international circumstances also for three reasons.

- First of all, because borders are crossed, regulation can only be international (IAEA Regulations for the Safe Transport of Radioactive Material, UN Model Regulations).

- Secondly, as the French producer AREVA operates abroad and as, according to the Vienna Convention on Civil Liability for Nuclear Damage, the operator of a nuclear facility (AREVA's customers, i.e. utilities such as EDF or others) is responsible for the damage should a nuclear accident could occur, we must take a wider approach in order to assess the governance of uranium in the transportation field.

- Thirdly, international regulation, especially in this matter, is the fruit of constant exchanges between the different players involved from governments or from the industry. Thus ASN tries to 'intervene as far upstream as possible in the elaboration of these rules', as its former Chairman, André-Claude Lacoste, explained. Both the UN and IAEA regulations are indeed regularly updated. Therefore drawing a line between international and national regulation seems artificial.

95 This represents less than 2% of dangerous materials transported each year.
96 Source: WNTI website, accessed May 2013.
97 Frédérique Vallon, La Mer et son droit, entre liberté et consensualisme, l'épineux problème du transport maritime des matières nucléaires, Publibook, Paris, 2013, p. 59.

The international body of rules on the transportation of radioactive material, which France applies, is made up of the following texts:

- The European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) drawn up by the UN Economic Commission for Europe.

- The regulations concerning the International Carriage of Dangerous Goods by Rail (RID) drawn up by the Intergovernmental Organization for International Carriage by Rail (OTIF).

- The International Maritime Dangerous Goods Code (IMDG Code) drawn up by the International Maritime Organization, applicable in France since 1987.

- The Technical Instructions for the Safe Transport of Dangerous Goods by Air drawn up by the International Civil Aviation Organization.

- Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public from the dangers arising from ionizing radiation.

- Regulation 1493/93/Euratom of 8 June 1993 on shipments of radioactive substances between Member States

The international regulations have been passed into the French law, especially through the joint ministerial decree on the transportation of dangerous goods (known under the name '*arrêté TMD*'), adopted in 2009.

In France, ASN has been the competent body for controlling the safety of radioactive and fissile material dedicated to civil use since 1997, while the two 'high civil servants' for defence (HFDS) placed under the Ministry of Defence and under the Ministry of Energy are in charge of security. Basically, roles are divided according to the two fundamental principles that form the basis of the regulation of radioactive material transportation in France, whatever the origin and intensity of the radioactivity:

- Protecting human beings from radioactive material, which governs the safety approach (ASN and IRSN competency)

- Protecting radioactive materials from human beings, which is at the heart of the security approach (HFDS).

To implement its role, ASN has put in place a system of control similar to that existing for nuclear installations (INB), with regular inspections. Around 900,000 containers are sent yearly in 600,000 transports in France. The nuclear industry's share in this figure is about 15%, including 85% of the transports dealing with materials used in the health, research or non-nuclear industry sectors (30% for the medical sector only). The yearly number of transports requested by the fuel cycle is about 11,000 (141,000 containers), among which 1,000 come from abroad, are directed to other countries or are transiting through France. Transports of natural uranium are to be found in this category.

In practice, ASN interacts with the different authorities competent for controlling hazardous goods – radioactive material being classified under 'Class 7' in the international classification – which differ according to transportation mode, as shown below. At field level, inspections and checks are carried out by inspectors for ground transportation distributed in each of the twenty-two French regional directorates for the environment. The HFDS's competence on security extends to the whole, knowing that he can forbid a transport at any moment, as well as the use of a particular port. Most sensitive transports (especially the used fuel sent for reprocessing to La Hague) are monitored by satellite and escorted by the Gendarmerie Nationale.

When they arrive in port, containers are inspected by the state representative and the company's transport supervision staff, but they are not opened unless customs demand it. Otherwise they will only be opened in the conversion facility.

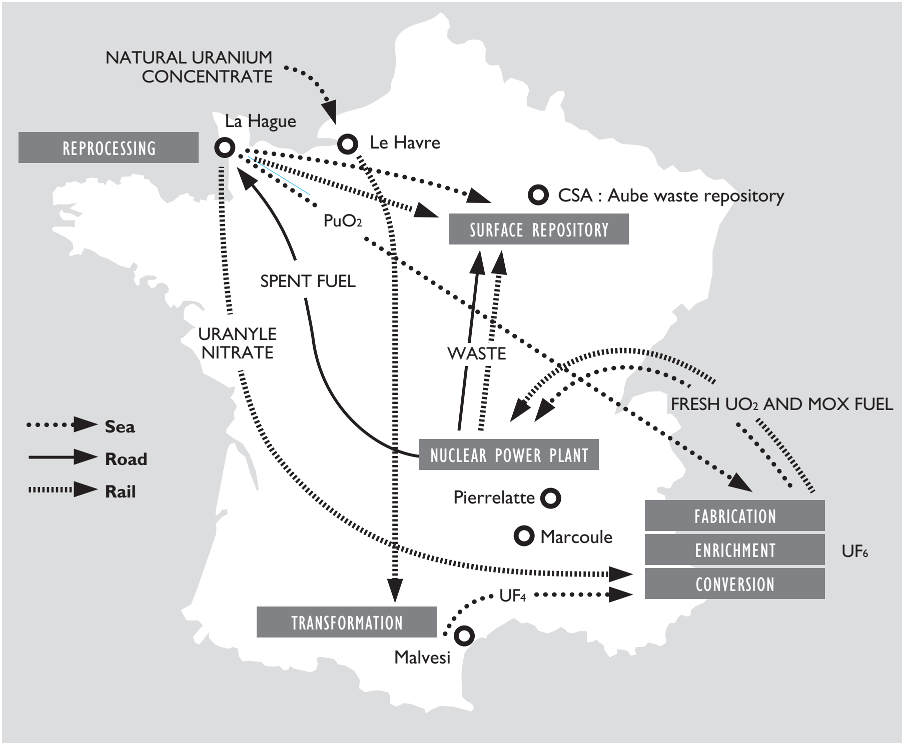
Competent services and institutions for controlling transportation mode and containers

Transportation mode	Competence for controlling the transportation mode	Competence for controlling the containers
Sea	Directorate General for infrastructures, transports, and sea (DGTIM), Ministry for Ecology, Sustainable Development and Energy	DGTIM in close coordination with ASN
Road, railroad	Directorate General for Energy and Climate, Ministry for Ecology, Sustainable Development and Energy	Directorate General for risk prevention in close coordination with ASN
Air	Directorate General for civil aviation (DGAC), Ministry for Ecology, Sustainable Development and Energy	DGAC in close coordination with ASN

Transportation modes are chosen according to five driving principles: risks at stake, volume of goods to transport, radioactive strength of the drum, distance to be covered, and number of handling operations. In radioactive material transportation, railroad transport is considered the safest way for large convoys, road as a flexible means of transport, sea as the best mode of transport for long-distance journeys, and air as the best mode of transport for urgent and long-distance transport (medical purposes).

In France, the transport of natural uranium is by sea and rail: natural uranium is unloaded from ships in France (Le Havre), Belgium (Antwerp) or Germany (Hamburg) to be loaded on trains to AREVA's Comurhex plant in the south of France. The ports of Fos, Sète and Montoir de Bretagne were also used. Each port has its own rules (regional competence), and tensions between the administrative authorities and dockyard workers unions are not unusual, which may result in delays in the unloading process. In such cases, the whole plan needs to be reviewed, as special freight trains charted for natural uranium transportation do not wait for the drums for security reasons. Each transportation plan is approved by the HFSD on a case by case basis, and no change can be made without his prior consent. In the case of road transportation, his opposite number in the companies is the security advisor, whose appointment is legally mandatory.

MAP OF RADIOACTIVE MATERIAL TRANSPORTATION IN FRANCE



Source: ASN Activity Report 2012, p. 336.

Principles of natural uranium transportation: containment and control

The industry operates under strict international safety and security rules. A failure to satisfy the legal requirements – unauthorized transport, transport made on unauthorized roads, lack of information about the goods being transported – are all offences carrying fines of up to 30,000 Euros and imprisonment for not more than one year. Two principles are at the heart of this regulation: containment and control.

Containment means that all measures must be taken so that the containers in which the materials are transported prevent all the risks related to radioactive material. Containment is defined according to the features of the transported material: the higher the risk, the higher the technical requirements imposed on the containers. In this respect, natural uranium is transported in containers labelled 'type A non-fissile', which are, for example, the same as those that transport radioelements for medical purposes. Uranium-bearing material extracted abroad from uranium mines is transported in France in 200-liter drums loaded in 20-feet containers or in traditional freight wagons. It is worth stressing that standardized 200-liter drums are only filled to about 70% of their capacity in order to satisfy the tare weight restrictions prescribed by the transportation simulations, which also depend on the nature of the ore. These wagons are dedicated to this kind of transportation. This type of drum is subject to different technical requirements but it does not have to be designed to withstand an accident, nor does it have to be licensed by ASN. The maker is responsible for its design and manufacture in such a way that the drum must withstand severe storms, a fall from a maximum height of 1.2 meters, compression equal to five times its mass, and a breach caused by the fall of a one-meter length bar. ASN provides a practice guide.[98] Ex-post controls by ASN inspectors are made to check whether the technical requirements are being fulfilled.

In its 2012 report, ASN points out that controls on non-licensable drums show an improvement in respect of regulation, but that there are still areas for improvement. However, this observation seems to apply much more to radioactive material for medical purposes. As for the industry (AREVA, EDF, CEA), three technical visits were conducted at the end of 2012 and an action plan was to be proposed in 2013. The analysis of incidents that occurred in 2012 does not refer to natural uranium transportation issues. If we look back, four incidents can be found:[99]

- In August 2008, a railcar carrying uranium ore concentrate from the Hamburg docks (Germany) to the Comurhex conversion plant at Malvési was found to be overloaded when entering France at Apach. The railcar was carrying 68 tonnes instead of the permitted 61tU.

- On July 26, 2007, a small spill of yellowcake was detected during the unloading of a container from a railcar at Comurhex's Malvési conversion plant. The container held 36 barrels of natural uranium concentrate (yellowcake) produced in Niger. It

98 ASN, Guide de l'ASN n°7 : Transport à usage civil de colis ou de substances radioactives sur la voie publique, 28 février 2013, http://www.asn.fr/index.php/S-informer/Publications/Guides-pour-les-professionnels/Transport-de-matieres-radioactives/Guide-de-l-ASN-n-7-Transport-a-usage-civil-de-colis-ou-de-substances-radioactives-sur-la-voie-publique. There is also a guide dedicated to « Regulatory demands applicable to radioactive material transportation in airport area », available on http://www.asn.fr/index.php/S-informer/Publications/Guides-pour-les-professionnels/Transport-de-matieres-radioactives/Guide-relatif-aux-exigences-reglementaires-applicables-au-transport-des-matieres-radioactives-en-zone-aeroportuaire.

99 Source: WISE Uranium Project, http://www.wise-uranium.org, accessed May 2013.

turned out that one of the uranium barrels had been damaged and that around 30 kg of yellowcake had spilled inside the container. Traces of spilled uranium were also found on the ship that had carried the container before the rail transport. The event was rated Level 1 on the INES scale (source: ASN, Aug. 9, 2007).

- On September 23, 2001, a railway car carrying 30 tons of uranium ore concentrates derailed at the Courbessac shunting yard near Nîmes (Gard) in southern France. The uranium originated from Niger and had been shipped via Benin and Brittany to the Comurhex conversion plant at Malvési near Narbonne (Aude). No uranium was spilled (source : *Le Midi Libre*, Sep 25, 2001).

- On June 8, 2000, the start of a fire was detected on a railway car carrying uranium ore concentrate (magnesium uranate) from Niger to Malvési. The fire was noticed at the entry of the Chantenay station (near Nantes), and the train was stopped. Fire brigades extinguished the fire within minutes. (Source: ASN)

The (pro)active role of the industry in the governance of uranium transportation

The safety and security of radioactive material transportation result not only from administrative governance but also from the co-construction of rules and practices between the regulator and the industry players involved: drum designer, drum maker, the owner of the radioactive material packaging, and the freight forwarded mandated by the principal organizer of the transportation.

The vital role of transportation has been acknowledged by the nuclear transportation industry, which has even created a dedicated international organization, the World Nuclear Transport Institute, which is much more than a promotional organization of its activities. Founded in 1998 by British Nuclear Fuels plc (BNFL), now International Nuclear Services (INS) of the United Kingdom, COGEMA now AREVA of France, and the Federation of Electric Power Companies (FEPC) of Japan, the WNTI gathers companies drawn from a wide range of industry sectors, including major utilities, fuel producers and fabricators, transport companies, package producers, and the production and supply of radioactive sources. It has consultative status with the IMO and observer status with the IAEA. In addition, WNTI has consultative status with the United Nations Committee of Experts on the Transport of Dangerous Goods.

'Do we see in the earnestness of the [nuclear] transportation industry a mostly economic concern or a publicly spirited attitude?' There is no easy answer to this question, which should certainly also target the communication and image concerns of the nuclear industry, as well as the role of anti-nuclear activists.

The principle of supervision: the example of Niger

Historically WNTI was created in order to deal with back-end transportation issues in the wake of the signing of a reprocessing contract between Japanese utilities and BNFL, which created a fierce debate. At the time front-end transportation issues were not on the radar of either the industry or of anti-nuclear activists, for the level of danger associated with such materials is much less. Little by little, though, the principles governing back-end transportation issues have been extended to the front-end, the first being the principle of supervision. There was no consensus within the industry, especially among the mining companies, who considered the very idea of uranium ore accountancy as useless and unrealistic.

Within AREVA, as of 2004, the decision was made to analyze and quantify the risks stemming from transport flows. A strong gesture was made in imposing the mining branch that cost could not be the only criterion for choosing a transport company. In the making of Transnuclear, an AREVA subsidiary and AREVA's transporter by default, a steering committee linked the Safety, Security and Health Department and the Risk and Insurance Department. Good practices were identified: any other transporter had to follow these practices and to go through a supervision examination. The quality of the transporter is a constant concern given the pressure from mining companies, which are reluctant to pay too much, and from transport companies themselves, for which carrying radioactive material is not financially attractive (small quantities with little added value) and very demanding in terms of procedures, whether at sea or in port. In selecting a transporter, AREVA goes beyond the international rules, applying its risk analysis method; attempts have been made to transform these criteria in international standards via WNTI, but up to now they are only referred to as good practices at the international level. Only three shipping companies have been accepted by AREVA. Locally in Niger, a qualification process and a training program have been put in place with local truck transporters.

In the same way, road transportation security measures from the mines to the port have been strongly reinforced. In Niger, uranium has to travel by truck to Parakou in Benin, which is 1,600 kilometers from Arlit mines. Outside the cities, the first major paved roads were constructed especially for transporting uranium from the northern town of Arlit to the Benin border in the 1970s and 1980s. This road, dubbed the Uranium Highway, runs through Arlit, Agadez, Tahoua, Birnin-Konni and Niamey, and is part of the Trans-Sahara Highway system. In Parakou, yellowcake drums are loaded on to trains which travel another 400 kilometers to Cotonou harbour, from where they are shipped to France. How should the security rules in the port of Cotonou in Benin be assessed? The nuclear and maritime lawyer, Fredérique Vallon, describes Cotonou as a 'good pupil',[100] – but her remark refers to the harbour's rules on imported hazardous material, not departing material. Cotonou's port is also where AREVA checks the drums stored in a buffer zone: following containment failure issues in 2004-2005, the drums were redesigned, with a secure locking system. Drums are strapped ('*cerclés*'). R&D has been conducted in recent years in order to produce a result where the lid is nearly fixed to the drum. The other point of attention is related to the way drums are strapped into the container. Captors measuring the speed acceleration of trucks have been set up in order to improve the strapping of the lid to the drum on the one hand and the strapping of drums into the container on the other hand. It is worth noting as well that inside the containers vinyl batches protect the strapped drums, thus forming a second barrier should a drum open.

There have been rumours of an alternative road through Algeria being considered, but we have found no serious source for this. Currently, the elapsed journey time is about three to four weeks (one week to ten days by road and rail, two to three weeks by sea); goods are shipped once a month according to ship availability and hazards on the road.

The whole journey takes place under a double monitoring process: a supervisor is present on site while the convoy is followed up from the operational response center near Paris. The journey takes place under armed escort, the Niger military to the border and then the Benin military. With the growing security threat in the Sahel zone,[101] security measures have been tightened.

100 Frédérique Vallon, op. cit., p. 45.
101 Chinese uranium prospector captured in Niger by Tuareg rebels in 2007, heavily armed men attack a camp of uranium prospectors in northern Niger (2007), kidnapping of seven AREVA, Satom, and Vinci workers in 2010, suicide attacks against Somaïr employees in May 2013.

Enhancing non-proliferation: controlling, authorizing and declaring

In France, export and import regulation of natural uranium is shaped by two factors: France's status as a nuclear-weapon state (NWS), and its EU member status. Regulation is driven by a basic principle: any transfer of nuclear material between France and another country, whether an EU member or not, entails that nuclear materials have to respect the provisions of one or several treaties or agreements. France's imports and exports of natural uranium indeed form a three-layer construction, made up of agreements signed by the European Commission (EC), those related to IAEA safeguards implementation, and France's own bilateral agreements. In this field, the question for domestic regulation is how France implements the different set of rules defined at both the international and European levels.

Importing and exporting: authorizing and declaring

In the field of non-proliferation, the pivotal regulatory basis is the 2009 EC Regulation on export controls of dual-use items and technologies[102] and EURATOM regulation 302/2005, under which any transfer of nuclear materials is to be notified to the EC. In practice, this piece of legislation has led to a simplification of organization. In applying the EC 2009 regulation, French domestic legislation has recently been modified[103] so as to simplify the process: one unique service is competent to examine the application and deliver the authorization, under the umbrella of the Ministry of Industry (in the previous system, customs issued the authorization). It is organized around two principles:

- Any export of nuclear material is subject to prior authorization.

- There are no import licenses in France, but importers may apply for a 'certificate of importation'. Exporting countries may require an 'end-user certificate'. This question is an issue and generates regular exchanges between the industry and the French administration, especially when the industry concludes a deal with a customer from a third-party country (i.e. neither France nor a country where uranium is extracted) which does not involve a transfer through France.

102 Regulation CE 428/2009, May 5, 2009.

103 Decree 2010-292 of March 18, on « procédures d'autorisation d'exportation, de transfert, de courtage et de transit de biens et technologies à double usage et portant transfert de compétences de la direction générale des douanes et droits indirects à la direction générale de la compétitivité, de l'industrie et des services ». Journal Officiel, March 20 2010.

Controlling

It is useful to recall that, while IAEA controls target states and are focused on the goal of non-proliferation, EURATOM controls are made on the users of nuclear material and aim to verify *ex post* that there is no discrepancy between the use mentioned in the *ex ante* declaration and the actual use made by the registrant (e.g. a utility or an enricher). In brief, the latter makes compliance verification, while the former's concern is use verification.

In order to follow the numerous commitments agreed by France in the fields of non-proliferation and nuclear cooperation, a specific organization has been put in place in which all the administrative bodies are represented. The system is placed under the umbrella of the Prime Minister, where the Technical Committee EURATOM (Comité Technique EURATOM or CTE) plays a pivotal role. Created in 2005,[104] CTE is responsible for:

- Ensuring technical coordination for implementing EURATOM provisions, including preparing and following up the different technical groups required by all the chapters of the treaty.

- Following up the implementation of controls over nuclear materials in France by the EC, for whom it acts as a contact point in this field.

- Coordinating implementation of the agreements concluded between France, the EAEC and the IAEA regarding the safeguards.

In fulfilling its missions, CTE is technically seconded by the Service for the Implementation of International controls (SACI), which depends on the Service of Defence Nuclear Expertise, itself part of the IRSN. In 2010 and 2011, 47 EURATOM and IAEA missions were accompanied by IRSN, for SACI carries out concrete and field actions such as:

- Managing the different declarations required by treaties and agreements.

- Preparing and accompanying international inspections.

104 Decree 2005-1283, October 17, 2005.

- Analyzing the technical documentation required from the organizations and structures targeted by the international controls.

- Assisting and advising nuclear operators in fulfilling the obligations required under international regulations.

- Analyzing and following the evolutions of national and international regulations.

The other public bodies involved are:

- The Ministry of Foreign and European Affairs, in charge of following up the implementation of agreements signed by France and of promoting France's actions regarding non-proliferation, arms control and disarmament.

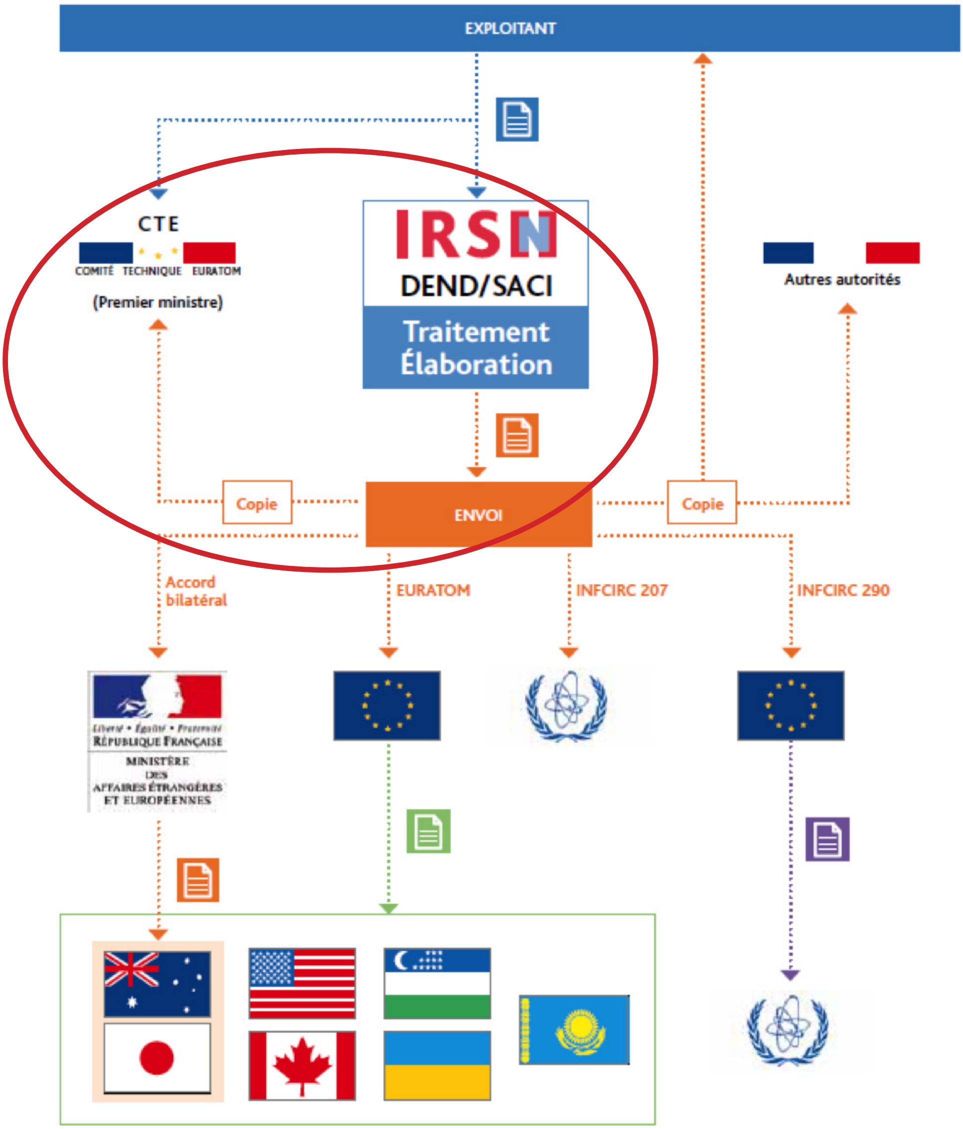
- The Ministry of Ecology, Sustainable Development and Energy, which is part of the definition of France's energy and nuclear policy.

- The Ministry of Defence, which plays a role in controlling nuclear materials and the elaboration of France's non-proliferation policy.

- The CEA, as its International Director, is the governor for France at IAEA.

In practice, CTE and SACI are the only entry points for any notification of nuclear material exports and imports. They are notified of any movements of materials, which they report to the EURATOM level. This centralization ensures both efficient action and easy use for operators ('*exploitants*'). The following scheme demonstrates the centrality of their role.

ADMINISTRATIVE GOVERNANCE OF NUCLEAR MATERIAL TRANSFERS IN FRANCE



Recent years have witnessed a huge regulatory process regarding the governance of nuclear materials in France. 2011 saw the climax of this round with the completion of the regulatory framework. In November of that year, France welcomed an IAEA International Physical Protection Advisory Service (IPPAS) mission, following its participation in the International Conference on Safety and Security of radioactive material transportation held in Vienna in October. IRSN has positioned itself particularly in relation to a new action regarding the remote identification of nuclear material, as well as in the definition of requirements regarding the monitoring process for these materials. These actions take place in the wake of its cooperation with the US Department of Energy, which includes, among other fields, a comparison of the rules applicable on nuclear security. Cooperation also exists within the EU framework with the creation of an ad hoc expert group on nuclear security in July 2011, aiming at sharing best practices and improving them.

The rules applying to the governance of natural uranium already form a complex and dense corpus which contrasts with the basic content of uranium selling contracts. They are indeed very similar to those that exist for other commodities. A standardized uranium selling contract typically includes price, point of delivery (a conversion facility or fuel fabrication facilities), the 'flag' (EURATOM/national codes) and possibly, but not necessarily, the origin – utilities having different practices in this matter.

MATCHING EURATOM/NATIONAL CODES

	EURATOM	CEA code	National	Future National Codes
Material subject to the Euratom-Australia Agreement	S	23	63	O S BN
Japanese material subject to the Euratom-Australia Agreement	S	13	83	O S JA
Obligated ('matières colorées') Japanese material subject to the Euratom-Australia Agreement	S		73	O S CJ
Material subject to the Euratom-Canada agreement	C	27	67	O C BN
Japanese material subject to the Euratom-Canada	C	17	87	O C JA
Obligated ('matières colorées') Japanese material subject to the Euratom-Canada Agreement	C		77	O C CJ
Material subject to the Euratom-USA agreement	A	25	65	O A BN
Japanese material subject to the Euratom-USA agreement	A	15	85	O A JA
Obligated ('matières colorées') Japanese material subject to the Euratom-USA Agreement	A		45	O A CJ
Swiss material subject to the Euratom-USA agreement	A	36	76	O A CH

	EURATOM	CEA code	National	Future National Codes
Material subject to the Euratom-USA and Euratom-Australia agreements	T	34	74	O T BN
Japanese material subject to the Euratom-USA and Euratom-Australia agreements	T	14	84	O T JA
Obligated ('matières colorées') Japanese material subject to the Euratom-USA and Euratom-Australia Agreement	T		44	O T CJ
Materials subject to Euratom-USA and Euratom-Canada Agreement	D	20	70	O D BN
Japanese material subject to the Euratom-USA and Euratom-Canada Agreement	D	10	80	O D JA
Obligated ('matières colorées') Japanese material subject to the Euratom-USA and Euratom-Canada Agreement	D		40	O D CJ
Material subject to a peaceful clause and under IAEA safeguards	P		42	O P BN
Material subject to a peaceful clause out of IAEA safeguards	P	21	71	N P BN
Japanese material subject to a peaceful clause	P	11	81	O P JA
Obligated ('matières colorées') Japanese material subject to a peaceful clause	P		72	O P CJ
Swiss material subject to a peaceful clause	P		41	O P CH
Government engagement with materials under safeguards	N		47	O N BN
Japanese material with government engagement	N	04	91	O N JA
Obligated ('matières colorées') Japanese material with government engagement	N		50	O N CJ
Swiss materials with government engagement	N		46	O N CH
Materials with government commitment to peaceful use	N	24	61	N N EP
Material subject to the Euratom-UK Agreement (imported prior to 01/01/1973)	N	26	66	N N EP
British- origin material (imported from 01/01/1973)	N	29	69	N N UK
Materials under special agreement	N	0B, 0C, 01, 02		N N LE
Materials attributable to defense requirements	N	00	60	N N LE

CONCLUSION

The governance of natural uranium in France is the result of a long and complex process, characterized by two paradoxes. First, in spite of a history of seven decades, it is only fairly recently that this governance has been shaped in a specific regulatory corpus. It is not that this governance was weak or seen as a non-issue: its backbone mostly consists of the European rules set up within the EURATOM treaty and of international rules, both of which enjoy the highest rank in the French legal system. What is more, France's general public law, which gives a large role to the state, was in many respects well adapted to the nuclear issue, without the need to resort to specific pieces of legislation. The second paradox has to do with the coexistence between the 'hypercentralization' of French nuclear governance and the constant tensions that exist between the different players involved. The French state itself, being at the same time a regulator of nuclear activities, the major shareholder of the French nuclear industry and the decision-maker as far as the French nuclear deterrent is concerned, carries in its heart many contradictions.

The existing tensions within the French governance system of natural uranium do not jeopardize its efficiency, which is mirrored by the rather good record of France in this field. Nevertheless, at a time when the French nuclear landscape is becoming more complex, with the relative autonomization of some of its players, it is only right to admit that the efficiency of the nuclear governance 'demands an ever increasing level of cooperation between public and private actors, and the states'[105]. This is very true for uranium, even if, in the French view, its status has long been uncertain, between 'normalizing' a commodity and securing a strategic asset. According to author Gabrielle Hecht, historically 'The director of the French CEA also decided to treat uranium as a '*banal civilian fuel' subject to commercial considerations.* In 1976 this perspective led the CEA to slice its fuel-cycle activities into a separate company called COGEMA. In France, however, institutionalizing the banality of nuclear fuel was contentious.'[106]

105 Jean-Pierre Mignard, Sébastien Mabile, Michel Mabile, Pascale Idoux, Sûreté nucléaire, droit et gouvernance mondiale, Bruylant, Bruxelles, 2012, p. 12.
106 Gabrielle Hecht, op. cit., p. 69.

Is this debate settled? In the *uranium industry*, certainly not, for the very reason that there has never been any debate: uranium is first and foremost seen as a commodity. But in the *nuclear community* – industry, shareholders, regulators – as a whole, the debate is over: security has become the keyword as far as uranium is concerned, whatever its status in the nuclear fuel cycle. This means security of supply, of course, as it always has since the 1950s, but more and more security as physical protection too. In a country where plutonium is separated and transported, the physical protection of natural uranium is clearly not the main target of the governance system. But one can only acknowledge that the measures taken to protect both natural uranium and the population have benefited from the very high level of measures put in place for the protection and security of very radioactive and sensitive material such as spent fuel or enriched uranium. The general attitudes of the actors in this governance system are shaped and influenced by the highest security standards that have been put in place for the most dangerous material. The culture of safety and security which is so strong in the back-end has irrigated the whole system of governance. From that point of view, the very existence of a fuel-cycle-integrated structure – COGEMA previously, AREVA today – has helped unify a strong safety and security culture.

This governance appears to be at the confluence of three factors, shaped by a triptych formed by 'the rule of law, professionalism always concerned about improvements and a vigilant civil society. Democracy, a high technological level and international cooperation – here are gathered the three conditions necessary for any improvement in the field of safety' and security'.[107] In this respect, it is a story that continues to be written each and every day.

107 Jean-Pierre Mignard, Sébastien Mabile, Michel Mabile, op. cit., p. 13.

APPENDIX I

DETAILED DATA OF TRANSFERS OF NATURAL URANIUM TO AND FROM FRANCE (2006 – 2009)[108]

Data on transfers of natural uranium for 2006:

- Total imported: 13,167tU.
    - 9,289tU to COMURHEX Malvesi
    - 3,869tU to EURODIF Pierrelatte
    - 5tU to FBFC Romans-sur-Isère
    - 3.2tU to EDF installations
    - 0.1tU to COMURHEX Pierrelatte
- Total exported: 4,088tU
    - 1,736tU to Russia
    - 1,403tU to Germany
    - 935tU to the Netherlands
    - 9tU to Belgium
    - 1.8tU to the United Kingdom
    - 1.5tU to Sweden
    - 0.2tU to Canada
- *Balance: net imports 9,079tU*

108 Ministère de l'écologie, du développement durable et de l'énergie, Annex to Estimation des importations et exportations de matières nucléaires à partir des données émanant du contrôle national relatif à la protection de ces matières contre tout acte de malveillance, undated document, HCTISN website, accessed January 2013.

Data on transfers of natural uranium 2007:

- Total imported: 13,961tU
    - 11,646tU to COMURHEX Malvesi
    - 2,298tU to EURODIF Pierrelatte
    - 3.6tU to FBFC Romans-sur-Isère
    - 2tUto EDF installations
    - 0.2tU to COMURHEX Pierrelatte

- Total exported: 3,796tU
    - 1,464tU to Russia
    - 1,245tU to Germany
    - 1,071tU to the Netherlands
    - 8.2tU to the United Kingdom
    - 3tU to Sweden
    - 0.2tU to Belgium
    - 0.03tU to Canada
    - 0.01tU to the United States

- *Balance: net imports 10,165tU*

Data on transfers of natural uranium 2008:

- Total imported: 11,002tU
    - 9,910tU to COMURHEX Malvesi
    - 1,084tU to EURODIF Pierrelatte
    - 5tU to EDF installations
    - 1tU to FBFC Romans-sur-Isère

- Total exported: 6.883tU
    - 1,803tU to Poland
    - 1,695tU to Germany
    - 1,677tU to Russia
    - 1,269tU to the United Kingdom
    - 425tU to Japan
    - 7tU to Belgium
    - 4tU to Sweden

- *Balance: net imports 4,119tU*

Data on transfers of natural uranium 2009:

- Total imported: 10,428tU
  - 9,173 tU to COMURHEX Malvesi
  - 1,247 tU to EURODIF Pierrelatte
  - 4 tU to EDF installations
  - 3tU to FBFC Romans-sur-Isère
  - 0.3tU to COMURHEX Pierrelatte
- Total exported: 5.262tU
  - 1,821tU to the Netherlands
  - 1,695tU to Russia
  - 1,480tU to Germany
  - 299tU to India
  - 8tU to Sweden
  - 4tU to the United States
  - 0.4tU to the United Kingdom
  - 0.1tU to Canada
  - 0.08tU to Japan
- *Balance: net imports 5,166tU*

APPENDIX II

BREAKDOWN OF EDF CONSUMPTION OF NATURAL URANIUM BY CONVERSION PLANT

	COMURHEX (France)	TENEX (Russia)	CONVERDYN (USA)	CAMECO (Canada)	Total
2008[109]					
Canada	2,250		100		2,350
Kazakhstan	830	1,000			1,830
Niger	1,550				1,550
Australia	710		360		1,070
Uzbekistan	270	400			670
United States	250				250
South Africa	220				220
Namibia	1000				100
Czech Republic	40				40
Total	**6,220**	**1,400**	**460**		**8,080 t (U308)**
2009[110]					
Australia	655		995	325	1,975
Canada			240	1,560	1,800
Niger	1,700				1,700
Kazakhstan	460	1,005		55	1,520
Uzbekistan	400				400
Germany	205				205
United States	125				125
Namibia	95				95
Russia			90		90
Total	**3,640**	**1,005**	**1,325**	**1,940**	**7,910 t (U308?)**

	COMURHEX (France)	TENEX (Russia)	CONVERDYN (USA)	CAMECO (Canada)	Total
2010[111]					
Kazakhstan	720	1,665		375	2,760
Niger	2,080				2,080
Australia	465		580	100	1,145
Canada			30	645	675
Namibia	250				250
United States			175		175
France	120				120
Total	**3,635**	**1,665**	**610**	**1,295**	**7,205 (U3O8?)**

109 HCTISN, Avis sur la transparence de la gestion des matières et des déchets nucléaires produits aux différents stades du cycle du combustible, op. cit., p. 38. In addition to natural uranium, EDF plants used 615 tons of French recycled uranium (converted in Russia), amounting to a total consumption of converted uranium of 8.695 tons.

110 Ministère de l'écologie, du développement durable, des transports et du logement, Bilans 2009 et 2010 des flux et stocks de matières, 15 September 2011, p. 9. Excluding recycled uranium.

111 Ministère de l'écologie, du développement durable, des transports et du logement, Bilans 2009 et 2010 des flux et stocks de matières, 15 September 2011, p. 10. Excluding recycled uranium.

APPENDIX III

FRANCE'S PAST AND CURRENT NUCLEAR COOPERATION AGREEMENTS

Source: James F. Keeley, A List of bilateral civilian nuclear co-operation agreements, vol. 2: Afghanistan-German Democratic Republic, University of Calgary, pp. 162-205, 2009.

Countries (number of agreements expired/ in force or with unknown termination)	Expired agreements explicitly mentioning uranium cooperation (date of signature, of termination)	Intergovernmental general cooperation agreements mentioning nuclear, intergovernmental nuclear cooperation agreements, specific uranium agreements with unknown/ unspecified duration termination date/with a provision for periodical review (date of signature)
Algeria (2/3)		Protocol on Economic Co-operation (1982, reviewed after four years)
		Agreement on the Use and Development of Nuclear Energy for Peaceful Purposes (2007): includes fundamental research, technology transfer, training, electricity production, and prospecting for and exploitation of uranium.
Argentina (1/9)		
		Cultural, Scientific and Technical Co-operation – includes nuclear co-operation (1967)
		Agreement signed by the Centre for Research in Uranium geology (1986) – includes prospection
		Nuclear Co-operation (1992)
		Co-operation in the Exclusively Peaceful Use and Non-Explosive Use of Nuclear Energy (1994)
Australia (2/5)		Nuclear transfers (1980, 1981)
	Agreement to Enable Conversion and/or Enrichment in France of Australian Origin Nuclear Material Supplied to Japan (1980-1981)	
Austria (0/3)		Scientific and technical cooperation (1968)
Bangladesh (1/0)	Co-operation for the Utilization of Nuclear Energy for Peaceful Purposes (1980-1990)	
Belgium (1/5)		

Countries (number of agreements expired/ in force or with unknown termination)	Expired agreements explicitly mentioning uranium cooperation (date of signature, of termination)	Intergovernmental general cooperation agreements mentioning nuclear, intergovernmental nuclear cooperation agreements, specific uranium agreements with unknown/ unspecified duration termination date/with a provision for periodical review (date of signature)
Bolivia (0/1)		CEA exchange of Letters on mineral prospection (1971)
Brazil (1/5)	Cooperation in the peaceful uses of atomic energy (1962-1974)	Scientific and technical cooperation (1968)
		Uranium plant contract (1976)
		Scientific and Technical Cooperation in the Field of the Peaceful Uses of Nuclear Energy (2002)
Bulgaria (1/3)		Scientific and technical cooperation (1966)
	Long-Term Agreement on Economic, Industrial and Technical Co-operation (1986-1996)	
Canada (1/4)		Exchange of Letters concerning the Canada; EURATOM agreement on the Peaceful Uses of Nuclear Energy (1981).
Central African Republic (0/2)		Uranium Mining Agreement (1967)
		Creation of uranium mining company (1968)
Chile (0/1)		
China (3/13)		
NB : since 2009		Scientific and technical cooperation (1978)
		Cooperation for the Utilization of Nuclear Energy for Peaceful Purposes (1997)
		Implementation agreement of the 1997 agreement (2007)
Columbia (0/1)		
Czech Republic (1/9)		Protocol on scientific exchanges (1964)
		Long-term Agreement on Economic, Industrial and Technical Co-operation (1986)
Egypt (1/3)		Peaceful uses of Nuclear Energy (1981)
European Union (0/1)		
Germany (2/14)		
Greece (0/1)		
Hungary (1/3)		Scientific and technical cooperation (1983)

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India (2/19)	Peaceful uses of Nuclear Energy (1965-1975)	Peaceful uses of Nuclear Energy (2008)
		Confidentiality of technical data (2010)
Indonesia (2/3)	Peaceful uses of Nuclear Energy (1969-1979)	
	Geology and Mineral exploration (1979-1982)	
Iran (1/3)	Nuclear cooperation (1974-1984)	Uranium prospection and exploitation (1961)
		Uranium prospection and exploitation (1969)
Iraq (1/1)	Peaceful uses of Nuclear Energy (1975-2001)	
Israel (0/3)		Cooperation on uranium phosphate (1954)
Italy (1/10)		University, scientific and technical cooperation on nuclear energy (2010)
Japan (4/26)		Peaceful uses of Nuclear Energy (1972)
Jordan (0/1)		Peaceful uses of Nuclear Energy (2008) refers to uranium exploration and exploitation
Kazakhstan (0/2)		Friendship and cooperation (1992)
		Peaceful uses of Nuclear Energy (2011)
Korea (1/9)		Peaceful uses of Nuclear Energy (1974, 1981, 1985)
Libya (0/6)		Peaceful uses of Nuclear Energy (2007) – refers to uranium exploration and exploitation
Lithuania		
Luxembourg (0/5)		
Mexico (0/4)		Peaceful uses of Nuclear Energy (1979) refers to uranium exploration and exploitation
		CEA agreement on prospection and exploitation of uranium (1980)
		Economic cooperation (1981)
Morocco		Preliminary accord on nuclear cooperation (2007)
Netherlands (0/1)		
Niger (0/3)		Agreement (1960). 'Note: WMDI reports that this agreement gave French companies a de facto monopoly over Niger's uranium'

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		Exchange of letters concerning the mining discovered by CEA + protocol specifying the mining conditions (1967)
Pakistan (0/4)		Nuclear cooperation (1976, 1991)
Philippines (0/1)		Peaceful uses of Nuclear Energy (1976)
Poland (0/2)		
Portugal 2		
Qatar (0/2)		Economic and financial cooperation (1974)
		Nuclear cooperation agreement (2008)
Romania (1/3)		Scientific and technical cooperation (1967)
Russia (7/17)	Peaceful uses of Nuclear Energy (1965-1967)	Peaceful uses of Nuclear Energy (1960)
		Scientific and technical cooperation (1966)
		Peaceful uses of Nuclear Energy (1967)
		Delivery on enriched uranium to France (1971)
		Scientific and technical cooperation (1990)
		Civilian nuclear security (1992)
		Peaceful uses of Nuclear Energy (1996)
Saudi Arabia (0/1)		Economic cooperation (1975); NB: unclear whether it came into force.
Slovenia 1		
South Africa (0/3)		CEA agreement on long-term supply of natural uranium (1964)
Spain (2/5)		
Sri Lanka (0/2)		Peaceful uses of Nuclear Energy (1980)
Sweden (0/4)		Joint studies in the field of metallurgy of uranium (1951)
		Atomic fuel (1969)
Switzerland (5/8)	Peaceful uses of Nuclear Energy (1957-1968; 1970-1990)	Peaceful uses of Nuclear Energy (1990)
Syria (0/1)		
Trinidad		Economic and technical cooperation (1978)
Tunisia (0/2)		Civilian nuclear cooperation (2008), including uranium prospecting

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Turkey (0/2)		Nuclear cooperation agreement (1999)
Ukraine (0/2)		Peaceful uses of Nuclear Energy (1998, to be terminated in 2020)
United Arab Emirates (0/2)		Cooperation (1980) and framework agreement (2008)
United Kingdom (1/9)		Supply of uranium slightly enriched (1955,1965)
		Nuclear cooperation (2008)
United States (24/19)	Civil uses of Nuclear Energy (1956-1966)	Uranium studies (CEA, 1960)
Uruguay 1		Peaceful uses of Nuclear Energy (exchange of letters, 1970)
Venezuela (0/1))		Scientific and technical cooperation in nuclear (1981)
Vietnam (0/2)		Peaceful uses of Nuclear Energy (1996, 2004)
Yugoslavia (6)	Scientific and technical cooperation (1966)	