WISE-Paris
Service Mondial d'Information sur l'Energie
World Information Service on Energy
http://www.wise-paris.org • e-mail : secretariat@wise-paris.org
31-33 rue de la Colonie F-75013 PARIS • Tél. +33 1 45 65 47 93 • Fax +33 1 45 80 48 58

Briefing for Greenpeace International

U.S. MOX "Lead Test Assembly" Controversy: Fabrication at Cadarache, France

If too dangerous for European fuel,
why just right for U.S. weapons plutonium?

Briefing LTA-ATPu
Version 1: **July 2003**

Authors : Xavier COEYTAUX*, Vincent LEGRAND*, Yves MARIGNAC**, Mycle SCHNEIDER***

Key words : *MOX – Lead Test Assemblies – plutonium disposition – ATPu – P0*

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*Research Associate, WISE-Paris; **Director of WISE-Paris; ***Independent Consultant

1. Introduction

The U.S. Government decided in April 2002 to terminate the immobilization track of the original "dual track" (mixed oxide fuel, or MOX and immobilization) to dispose of "surplus" military plutonium in favor of the more expensive " single track" MOX fabrication approach. The Duke Cogema Stone & Webster (DCS) joint venture chosen in 1999 to develop industrial scale fabrication facilities for MOX fuel from weapons-grade plutonium and to provide reactors for MOX irradiation, thus was charged with a larger MOX disposition program than earlier anticipated.

Following repeated delays in the implementation of the MOX fuel path, the U.S. administration began to pursue a European option for the fabrication of MOX Lead Test Assemblies (LTAs). Under the "Eurofab" option, weapons-grade plutonium would be transported across the U.S to an east coast port then shipped overseas to Europe, guarded by an armed escort vessel. LTAs would be produced in a European MOX fabrication facility using the weapons-grade plutonium, then shipped back to the U.S. to undergo test irradiation in one of the Duke Power reactors designated to use MOX on a commercial scale.

For political, technical and regulatory reasons, the project first focused on Belgonucléaire's P0 plant in Dessel, Belgium. In July 2002, the indefinite delay of the Belgian government decision on the issue turned the focus on the ATPu plant in Cadarache, France, presented as the second best option. Meanwhile, the French government and COGEMA, the operator of ATPu, have decided on the definitive closure of this old plant by 31 July 2003, in particular due to its poor anti-seismic design standards.

The French government has never stated publicly that it has been approached by the U.S. Department of Energy (DOE) to consider fabricating LTAs at Cadarache. This leads to a perfectly contradictory situation. On one hand, there is no indication that the low-paced closure process at Cadarache rules out the *technical* possibility of a decision to proceed with the LTA fabrication at ATPu. But on the other hand, it is obvious that such a decision would add to technical, regulatory and safety concerns that have led to the shut-down decision of ATPu in the first place.

The following paper assesses the nature and background of the Cadarache option. The document also analyzes, from a political, regulatory and technical point of view, the reasons why the LTA project targeted P0 in Dessel and ATPu in Cadarache. It discusses the range of problems posed by the project to produce LTAs at ATPu and highlights the controversy that this proposal has stimulated.

2. The LTA project and the European context

This chapter describes the context for the implementation of LTA production in Europe. It includes a short description of the MOX fabrication "system" in Europe and sets the political background of both the ATPu and P0 MOX plant operation.

2.A. The European role in the U.S. MOX project

2.A.1. The U.S. military disposition program development from a European perspective

Since the plutonium disposition agreement was signed on 1 September 2000 between the U.S. and Russia, the initial U.S. "dual track" option, i.e. fabrication into MOX for one part or the plutonium and immobilization in a waste form for the other part, has been progressively abandoned by the U.S. Due to political pressure by the plutonium industry, a "MOX-only" approach now remains in the U.S., which consists of the conversion of all surplus military plutonium into mixed uranium-plutonium oxide fuel (MOX) and its loading into commercial reactors.

The decision to abandon immobilization with existing high-level waste of 8.4 MT of plutonium of the original 34 MT declared surplus was made official by the U.S. Department of Energy's National Nuclear Security Administration (DOE/NNSA) on 19 April 2002. Thus, research into immobilization of plutonium in a ceramic form at DOE's Lawrence Livermore National Laboratory in California was terminated. Likewise, plans for construction of an immobilization facility at DOE's Savannah River Site (SRS) in South Carolina were abandoned. Thus, if the program fails, there is no back-up plutonium disposition option, which was a key basis for the dual-track approach.

Although the immobilization option *"achieves full disposition [...] of U.S. plutonium with the lowest cost"*, according to an unsubstantiated but official DOE assessment[1], the MOX option has been preferred due to alleged international considerations:

- the immobilization option *"would lead almost certainly to termination of bilateral plutonium disposition with Russia. Russia would have no incentive to complete disposition of its surplus plutonium"*
- *"this option would have limited support internationally"*.

The U.S. industry does not have any industrial experience in plutonium recycling and in MOX fabrication. The U.S. Department of Energy seeks the necessary know-how in Europe, where it has been built up by COGEMA (France), Belgonucléaire (Belgium), ALKEM (Siemens, Germany) and British Nuclear Fuels Limited (UK). Due to its expertise, COGEMA was included in the Duke COGEMA Stone & Webster (DCS) consortium, which has been awarded a Base Contract of $130 million in March 1999 to develop the U.S. MOX project.

COGEMA brought into the DCS consortium its experience in building and operating a MOX plant. The U.S. program includes the construction of a MOX fabrication facility at the Savannah River Site, based on the design of the French MELOX plant operated by COGEMA at the Marcoule site. The plant, with 101 tHM/a of annual capacity started production in 1995, and has applied for an authorization to extend annual MOX production to 145 tHM.

Between 8 January and 8 March 2003 the Gard Prefecture conducted a public inquiry into the MELOX license request. The inquiry has been boycotted by practically all of the environmental groups because the conditions for an open and democratic process did not seem to be present. The chairman of the inquiry commission transmitted his conclusions to the Gard Prefecture at the end of

[1] National Nuclear Security Administration Office of Fissile Material Disposition, *"Report to Congress: Disposition of Surplus Defense Plutonium at Savannah River Site"*, 15 February 2002.

May 2003[2], which in turn passed the dossier on to the Ministers in charge[3]. The last step of the procedure is now the publication of the decrees authorizing the MELOX extension, which can happen any time.[4]

The importance of the participation of the European MOX industry in the U.S. program is underscored due to repeated delays encountered by the DOE and the U.S. Nuclear Regulatory Commission (NRC) in the development and implementation of the project.

Specific development steps have been defined in the DCS Base Contract:

- Design and licensing of a plutonium/MOX fuel fabrication facility at the Savannah River Site;
- Design and licensing of nuclear reactor modifications at Duke Power Company's Catawba and McGuire Nuclear Power Plants near Charlotte, North Carolina and Rock Hill, South Carolina – all four reactors of which are of the controversial ice-condenser PWR type.[5]
- Qualification of plutonium/MOX fuel for use in U.S. light water reactors (LWR);
- Design and certification of a first-of-its-kind plutonium/MOX fuel shipping package;
- Fabrication and irradiation of plutonium/MOX fuel Lead Test Assemblies.

The last step, which includes fabrication of Lead Test Assemblies (LTAs), is an important step before commissioning of the future SRS MOX plant planned for 2008. LTA irradiation is crucial in order to qualify both the MOX fuel in the Duke reactors and the MOX fabrication process itself - the advanced MIMAS process - chosen for the SRS MOX facility. As LTA irradiation testing would take place over two irradiation cycles of 18 months each, with post irradiation examination taking about a year, DOE sees the European fabrication option as key to an early start of the U.S. MOX program. Fabrication of the LTAs in the SRS MOX plant would push start-up of the program to 2012 or beyond.

The DOE's Los Alamos National Laboratory in New Mexico, initially chosen as LTA fabricator, was unable to produce the LTAs of the quality needed, thus resulting in delays and negative cost implications for the entire MOX program. Subsequently, the U.S. administration began to analyze the European plutonium industries' ability to fabricate the LTAs in order to speed up the qualification process. In the event the European option does not go forward due to political or technical reasons, DOE continues to maintain the option of fabricating the LTAs in the SRS MOX plant, in spite of the delays in the program this would cause. In June 2000, the "Eurofab" plan emerged and became a major component of the European involvement in the U.S. plutonium disposition strategy.

The two remaining European companies interested in fabricating the LTAs, COGEMA and Belgonucléaire, support the Eurofab option arguing that it would be a perfect opportunity for them to contribute to international disarmament and non-proliferation. It is unclear why the U.S. Government has not turned to its closest European ally, the UK, with the request to fabricate the LTAs.[6] However, the main reason is probably that the UK MOX fabricator BNFL is not in a position to deliver MOX fabricated on the basis of the MIMAS process, chosen by the U.S. DOE for its weapons plutonium disposition program.

On the U.S. side, a potential difficulty could be faced due to U.S. environmental law. In order to carry out the Eurofab option, the DOE would have to ship, via truck, 150 kilograms of weapons-grade plutonium from the Los Alamos National Laboratory in New Mexico to an East Coast U.S. port, from which the material would be shipped to Europe. Overland and sea shipment become necessary as it is

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[2] Personal communication with M. Lafay, president of the MELOX public inquiry commission, 4/07/03

[3] Personal communication with the Gard prefecture, 04/07/03

[4] There is a longstanding French tradition to publish controversial decrees in the month of August when half of the French population is on vacation…

[5] Virginia Power Company's North Anna-1 and -2 nuclear power reactors are still listed as "mission" reactors in the contract though the company has since dropped out of the DCS consortium.

[6] "Llew Smith: To ask the Secretary of State for Defence what recent requests he has received from the United States Government to provide lead test assemblies for the United States military nuclear programme. [100038] Mr. Ingram**:** None. » The Hansard, 5 March 2003, Columns 1-1052W

illegal to fly such plutonium over U.S. territory. According to a “Draft Notice of Intent,”[7] DOE intended to prepare a supplemental Environmental Impact Statement (EIS) on both the “preferred” Eurofab and SRS options, as required by the U.S. National Environmental Policy Act (NEPA). Analysis of the Eurofab alternative would entail evaluation of the “potential impacts on the global commons” of sea shipment of plutonium oxide to Europe and return of fabricated MOX LTAs back to the Duke Power reactor chosen for the LTA testing. Vessels which might undertake the transport and armed escort duties for the plutonium sea shipment could be from the Pacific Nuclear Transport Limited (PNTL) fleet, largely owned by British Nuclear Fuels Limited (BNFL), or by the U.S. Navy itself.

Additionally, DOE would have to secure an export license from the Nuclear Regulatory Commission and this could face intervention by the public. As of the end of July 2003, no final “Notice of Intent” to prepare NEPA documentation has yet been published in the U.S. Federal Register.

2.A.2. The LTA fabrication requirements and the Eurofab option

The LTA fabrication is a process specific to the characteristics of the initial material used. The weapons-grade plutonium used to fabricate MOX is enriched to around 93% in Pu-239. The specific isotopic composition of weapons-grade plutonium implies a number of unique handling issues at every step of the fabrication process and raises questions about radiation protection and proliferation resistance. Weapons-grade plutonium is a fissile material of great strategic interest with regard to nuclear weapon fabrication. Use of it for MOX production necessitates increased safety measures in the fabrication process to avoid a criticality accident. As of June 2003, no public information had been released on how physical protection of the plutonium would be assured during its transfer between the U.S. and Europe, and no feasibility study with regard to the commercial MOX fabrication process in Europe has been issued.

Moreover, the age of the U.S. plutonium is an important factor with regard to radiation protection. The radioactive decay of plutonium isotopes produces sub-products such as plutonium-241 and americium-241 in particular, which raises radiation protection concerns. For example, the authorized level of americium in the plutonium treated at the MELOX plant should not be above a 3% threshold because of the radiation risk encountered by workers during the fabrication process. Moreover, MELOX is not licensed to handle plutonium with less than 17% of Pu-240, because of the criticality risks encountered with plutonium with lower quantities of isotopes insuring moderation efficiency.

Of the three MOX plants operated by COGEMA (ATPu at Cadarache and MELOX at Marcoule) and Belgonucleaire (P0 at Dessel), only ATPu and P0 could theoretically fabricate LTAs. If P0 were used, the actual MOX fuel assembly would have to take place in the nearby FBFC (Franco-Belge de Fabrication de Combustible) facility. The current licensing situation of FBFC for this task remains unclear.[8]

A sloppy regulatory framework of the ATPu and P0 plants and their flexible initial design features, which allows for the fabrication of plutonium fuels for Fast Breeder Reactors, i.e. fuels with high fissile content, would make the handling of U.S. plutonium theoretically possible at those facilities.

It remains unclear, if DOE originally proposed the Eurofab plan. It could well have been suggested by COGEMA, given the history of its “blackmailing” strategy with the French safety authority with regard to ATPu operation. This facility, which should have been closed down for good “just after year 2000”, according to the original deadline set by the French safety authority, will now stop

[7] U.S. Department of Energy, National Nuclear Security Administration, Draft *Notice of Intent to Prepare a Supplement to the Surplus Plutonium Disposition Environmental Impact Statement (Lead Mixed Oxide Fuel Assemblies)* ; 6 March 2002

[8] Even if Belgonucléaire states in a Note dated 10 April 02: “The fabrication in Belgium of demonstration MOX fuel using excess WPu [weapons-plutonium] at Dessel does not raise any technical difficulty, and may be performed in the frame of the existing MOX plants’ licenses (BELGONUCLEAIRE, as well as the nearby FBFC International which would be used to bundle MOX fuel rods into fuel ‘assemblies’).” http://www.belgonucleaire.be/uk/news.htm

"commercial" operation as of 31 July 2003, thanks to COGEMA's successful strategy to prolong its operational lifetime.

2.A.3. The MOX industry in Europe

The state of the European MOX industry is intrinsically linked to the situation of the reprocessing industry. Because plutonium fabricated into MOX fuel is extracted from spent nuclear fuel through reprocessing, industrial and political choices on spent nuclear fuel management are determining the MOX industry's future. With two countries, the United Kingdom and France, operating reprocessing facilities at Sellafield and La Hague, and four more countries, Belgium, Germany, Netherlands and Switzerland, clients of this industry, the size of the MOX market is still very limited. In fact, the four European MOX plants based in Belgium, France and United Kingdom currently supply MOX fuel for only four client countries, which are Belgium, France, Germany and Switzerland.

Table 1: Status of the Contracted and Reprocessed Spent Fuel at La Hague
(as of 31 January 2002, in tons of heavy metal)[9]

Client	Total Contracted	Total Reprocessed	Status of the Contract in %
France	13,406	8,360	62.4%
Germany	5,981	4,470	74.7%
Japan	2,944	2,944	100.0%
Belgium	671	671	100.0%
Switzerland	761	619	81.3%
Netherlands	383	269	70.2%

Of the four MOX clients, Belgium, which suspended reprocessing in 1998, did not sign and is not expected to sign any new contracts, Germany decided in June 2000 to end shipments to reprocessing plants in July 2005, and in Switzerland the new nuclear law will include a 10 year moratorium on spent fuel transportation for reprocessing purposes, starting in 2006. Moreover, renewal of the French MOX agreement with the national electricity utility Electricité de France (EDF) in October 2001 did not lead to increased MOX deliveries and, on top of it all, significant price reductions were consented by COGEMA.

Concerning the potential Japanese market, the freeze of the Japanese *Pluthermal Program* after quality-control scandals – first on the UK MOX manufacturing and then on the Japanese reactor side – led to indefinite delays of the MOX contracts with COGEMA.

In other words, the **French plutonium industry** is not only in trouble but in structural decline.

The situation of the **British plutonium industry** is even worse since it has been severely hit by the various quality-control scandals at a small MOX fabrication facility (MOX Demonstration Facility) and operational problems at its THORP reprocessing plant at Sellafield. Moreover, BNFL's recently-opened Sellafield MOX Plant (SMP), which started up in October 2001 thanks to the "economic justification" provided by German utility contracts, has been threatened in January 2003 with the cancellation of these very same contracts due to repeated delays of the commercial operation. The withdrawal of the German utilities would leave only a small quantity of Swiss MOX to be fabricated, an economic nightmare for the SMP operators. Likewise, Japan has failed to sign any MOX fabrication contracts with BNFL.

The recurrent problems encountered in the operation of the THORP reprocessing plant include particular safety and security problems caused by the storage and vitrification difficulties of huge stocks of liquid high level wastes and the unbearable cost burden for the electricity utility British

[9] Commission Spéciale et Permanente d'Information de La Hague, bulletin n°10, April 2002

Energy. Discharges into the Irish Seas of radioactive reprocessing waste from Sellafield reprocessing plants remains of deep concern to Ireland and the Nordic countries, which consistently undertake political and legal efforts to halt such discharge.

The **Belgian MOX fabrication plant P0** will most probably be closed down within the next two years. With the end of the German and Belgian programs and the indefinite delays in the Japanese plans, the MOX fabricator Belgonucléaire does not have further industrial prospects. The precise date of the fulfillment of the German and Belgian contracts remains difficult to estimate. Both clients combined currently account for two thirds of the plant's load factor.

In the beginning of the 1990s, COGEMA or COMMOX[10] as EDF contractor, represented two thirds of the plant's output. After COGEMA had pulled out of a "capacity reservation contract" that guaranteed work at the Dessel plant until 2006, in June 2002 Belgonucleaire decided to file a complaint against COGEMA in the arbitration court of the International Chamber of Commerce[11]. While the conflict between the two companies appears to have been settled by an agreement of unknown content, with the obvious decline of the MOX market in 2003, the P0 plant could still be threatened of closure by lack of clients as soon as 2004.

This short description of the current situation of the European plutonium industry certainly reflects the general tendency for the coming years. It appears that both the British and French plutonium industries will at best maintain their output at current levels while the Belgian MOX fabricator will disappear. But the possibility of an acceleration of the current decline cannot be ruled out, because of the general depreciation of the plutonium industry, including by national electricity utilities pushed towards massive savings as a consequence of the deregulation of the European electricity markets.

2.B. Possible MOX plants for LTA fabrication in Europe

In the absence of a domestic fabrication facility, the U.S. Government has selected Belgium and France for the possible fabrication of LTAs. However, the previous Belgian Government delayed any decision indefinitely. While the newly-elected Belgian Government does not have a Green Party component anymore, the same Prime Minister has been reappointed. A radical change in the attitude of the Belgian Government to the LTA issue is therefore not to be expected.

In France, it is unlikely that MELOX would be chosen for LTA fabrication. In fact, MELOX is not licensed to handle weapons-grade plutonium. Licensing MELOX to handle such material would be lengthy and LTA fabrication would seriously disturb commercial operation at the plant. The only remaining plant is therefore the ATPu facility operated by COGEMA at Cadarache.

The following part provides a more detailed overview of the P0 MOX plant operated by Belgonucleaire at Dessel and the COGEMA's ATPu facility at Cadarache.

2.B.1. The P0 facility at Dessel, Belgium

2.B.1.a Operational and regulatory situation: close to closure?

The P0 facility was commissioned in 1973 to produce plutonium-based fuels for Fast Breeder Reactors (FBRs). With an annual capacity of around 10 tHM/a of FBR fuel, P0 supplied MOX for the Belgian BR-2 research reactor and the German-Dutch-Belgian-UK never commissioned SNR-300 Kalkar breeder reactor for more than a decade. With the failure of the FBR programs and the subsequent development of LWR-MOX programs in Europe in the mid-1980s, P0 production turned to LWR-MOX in 1986. It was the first plant to experiment and apply the MIMAS process for MOX fuel fabrication. This process was later applied in the MELOX plant, which started production in 1995. Until the MELOX start-up, France had been the main client of the P0 plant with around 180 tHM of MOX produced for French LWRs.

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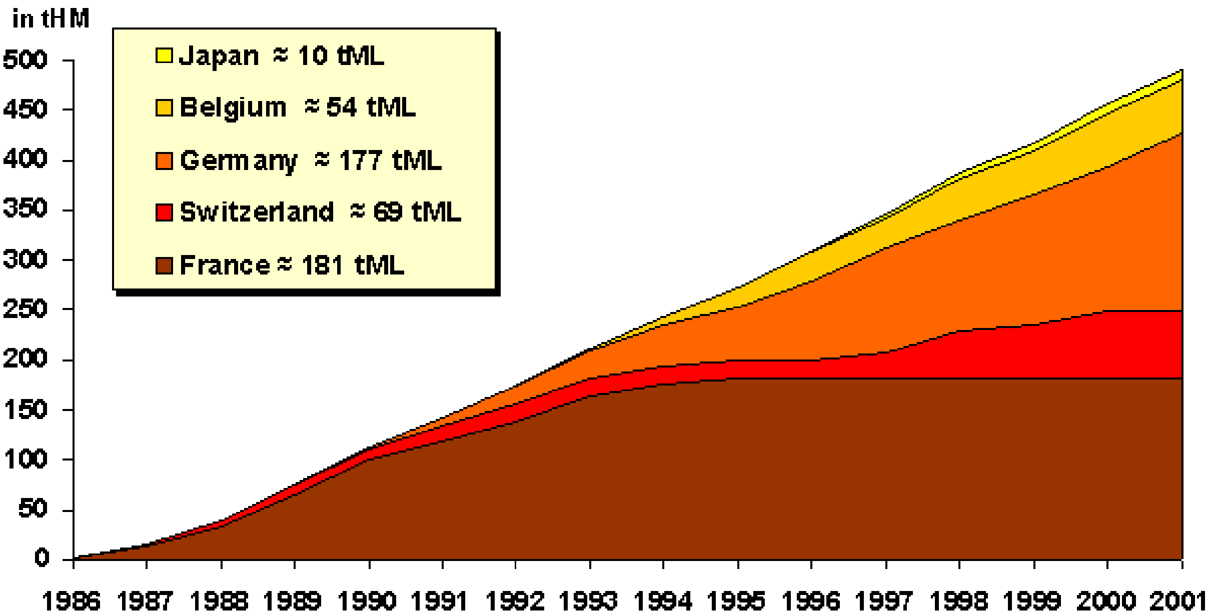
[10] COMMOX is a subsidiary of COGEMA (60%) and Belgonucléaire (40%)

[11] Nuclear Fuel, *"Arbitration of BN-COGEMA Dispute over MOX to take 'another few months'"*, 9 December 2002

In the 1980s Belgonucléaire was planning to extend the facility by adding two new production lines called P1 with a total annual capacity of 60 tons. However, the licensing procedures got stuck in court cases and the plant was never constructed. As soon as 1996, Belgonucléaire showed interest in U.S.-Russia agreements on military plutonium disposition, and raised the possibility of turning U.S. plutonium into MOX fuel.

Graph 1: Cumulated MOX Production of the P0 Plant, Breakdown by Client Country
(as of the end of 2001, in tHM)[12]



As of the end of 2001, cumulated production of P0 plant was 491 tHM of MOX[13]. In 2001, production of MOX at P0 was essentially limited to German clients, and production for Switzerland has been transferred to ATPu at Cadarache and SMP at Sellafield.

2.B.1.b The non-decision by the Belgian Government on the LTA fabrication

Although the Eurofab plan was announced in mid-2000, the evaluation of the specific strategy took several months, and French and Belgian governments had to deal with the plan only after the final U.S. decision in April 2002 to abandon immobilization. Because the P0 plant already licensed to use weapons-grade plutonium, essentially because it fabricated FBR fuels with high fissile content, Belgium was apparently asked first to fabricate the LTAs. Because of a political controversy inside the government on the issue, the decision was postponed in July 2002. The energy minister, from the Green Party, opposed the project. The way Belgian Prime Minister Guy Verhofstadt, under significant U.S. government pressure, attempted to push the issue through the last Cabinet meeting before the 2002 summer break led the Belgian government not to consider the proposal at all. In late December 2002, Belgium postponed its decision on the LTA proposal indefinitely. While the Green Party was eliminated from government following the May 2003 elections, it appears that the U.S. could once again be looking at LTA fabrication at P0 but political opposition remains.

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12 Sources:
A. De Backer, *"MOX Fabrication: External Communication at Belgonucleaire Dessel Plant in Belgium"*, International Seminar for MOX Utilisation, Tokyo Japan, 18 - 19 February 2002
Personal communication with A. De Backer, Belgonucleaire, 26 March 2001

13 R. Jacquet, Director of the MELOX plant, *"MOX fuel fabrication and its external communication in France"*, MOX seminar in Japan, February 2002

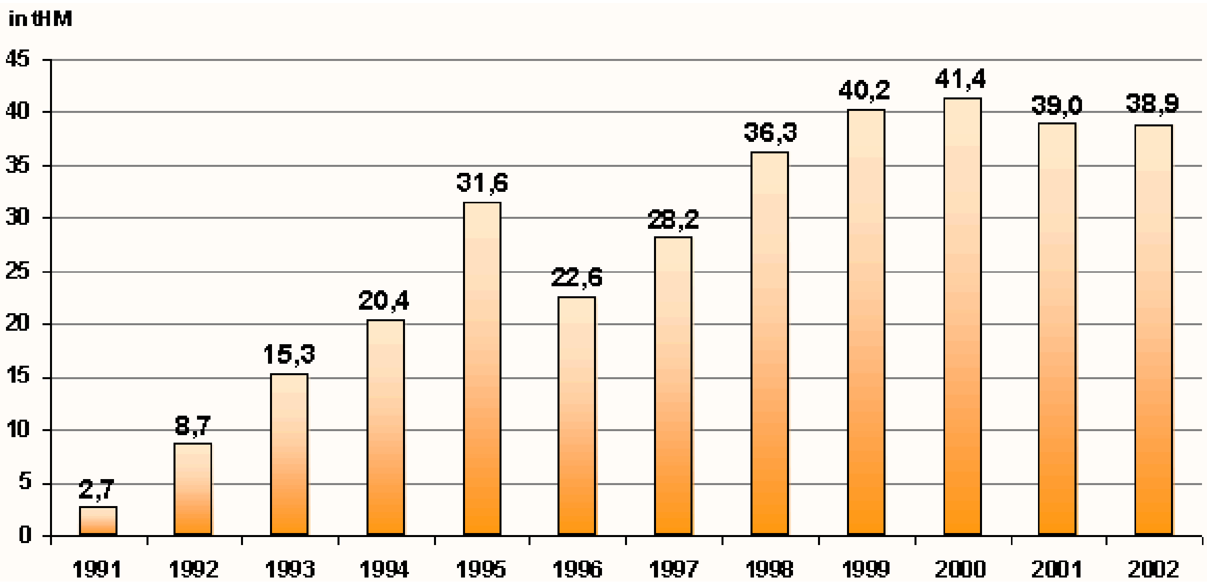
2.B.2. The ATPu facility at Cadarache, France

2.B.2.a Operational and regulatory situation: the "blackmailing" strategy of the operators

ATPu was created in 1961 to produce plutonium fuel for fast breeder (FBR) and light water (LWR) reactor experimental programs and was the first MOX production facility built in France. It is part of CFCa (Fabrication Complex of Cadarache), at Cadarache (Bouches-du-Rhône Department). While COGEMA is its "daily operator", the CEA (Commissariat à l'énergie atomique, the State Atomic Energy Commission) remains the operator in regulatory terms[14]. The regulatory situation of the ATPu is therefore everything but clear, to say the least.

ATPu produced fuels for French Phenix and Superphenix FBRs until the late 1980s (probably a total of around 105 tHM), but after 1990, when COGEMA became the plant operator, the plant production turned essentially to MOX for LWRs. Until 1996, when the plant was qualified by Siemens to produce German MOX, the plant had only produced MOX for French LWRs. After 1996, the plant produced LWR MOX exclusively for German electric utilities, with the exception of 2.2 tHM of FBR fuel produced in 1998-1999 for the Phenix FBR

Graph 2: Production of LWR MOX Fuel at ATPu at Cadarache
(as of the end of 2001, in tHM/a)



As of the end of 2001, cumulated production of ATPu was 286.4 THM

According to Gilbert Dalverny, Director of ATPu, 336 assemblies' worth had been produced for German utilities as of the end of 2001[15]. This should correspond to around 180 tHM of German MOX produced into rods because ATPu's design do not include an assembly line, assembling of ATPu's production takes place at the Belgian FBFC, a facility next to the P0 MOX fabrication plant, or at the French MELOX facility.

ATPu was built in a regulatory context when only limited nuclear safety rules were defined, a formal licensing procedure was lacking and operators could build nuclear installations on the basis of a

[14] COGEMA has been the industrial operator of the ATPu since 1991. CEA-Cadarache management indicates on its website that "having become a COGEMA establishment in 1991, CEA Cadarache (the CFCa) has found its place naturally in the COGEMA Group's fuel production cycle". However, the CEA remains the operator where safety is concerned. In the list of INBs (basic nuclear installations) established by the French nuclear safety authorities, no change in the authorization of the ATPu (INB n° 32) has been reported since its declaration of 27 May 1964 by the CEA. Decree n° 63-1228 of 11 December 1963, setting the rules applicable to INBs and especially their regime of authorization, nevertheless stipulates that a new authorization is necessary for a INB to change operator.

[15] NuclearFuel, n°26, *"COGEMA Prepares to Close up Shop at Cadarache MOX Plant Early 2003"*, 23 December 2002

voluntary declaration. In particular, no specific seismic rules existed at that time for the design of such facilities.

In the early 1990s the safety authority reevaluated the seismic resistance of the facility and discovered that the ATPu design was not at all adapted to the seismic risk level of the geographical area (see part 4.1). In 1995, the French safety authority planned to require the shut down of ATPu around year 2000. But only in January 2003, Anne Lauvergeon, chair of COGEMA/AREVA, finally announced that ATPu would stop commercial operation as of 31 July 2003. According to Jacques Aguilar, in charge of the fuel cycle department at the safety authority[16], the authority asked COGEMA to reduce the source term (radioactive inventory) by a factor of 10 before 31 July 2003. No details of the plan are known.

According to Gilbert Dalverny, director of COGEMA-Cadarache, some sort of production at ATPu could go on "*until 2006, in order to use all the production scraps as well as all stocks of plutonium initially dedicated to Superphénix.*[17]"[18]

The closure will only lead to a permanent safe state once the production has been stopped, and the site has been cleared of radioactive materials.

2.B.2.b The status of decision about the LTA fabrication in ATPu

The French safety authority stated in early July 2003 that no formal request had been received yet concerning the licensing of the production of LTAs at ATPu[19]. However, at a recent meeting of nuclear officials, hosted by the French Government, it was revealed that the U.S. Government has now officially approached the French Government with the request to allow for the fabrication of LTAs at ATPu. COGEMA has informed the safety authorities that it intends to shortly submit a licensing request for the shipping casks for the plutonium and the LTAs. The fabrication or the four LTAs is to be carried out in less than three months.

The French government, as of early July 2003, has made no announcement about the status of the program. Although the decision does depend on the French government, the French safety authority made it clear that ATPu was theoretically technically capable to fabricate LTAs. However, several top representatives of the French safety authorities have indicated in private talks that they do not wish a possible lifetime extension of ATPu in order to fabricate the LTAs.

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16 Personal communication with Jacques Aguilar, DGSNR, 13 February 2003.
17 Superphénix was a 1,200 MWe FBR, definitely shut down in 1997.
18 "*Anne Lauvergeon confirme la fermeture de l'usine Cogéma de Cadarache*", Anne Bauer, Les Echos, 21 January 2003.
19 Personal communication, Jacques Aguilar, DGSNR, 3 July 2003.

3. Problems raised by the use of weapons-grade plutonium at ATPu

This chapter focuses on the range of problems linked to the potential use of ATPu for the LTA program. The discussion covers both the weaknesses of the decision-making process and the concern about the decision in terms of safety and security.[20]

3.A The LTA fabrication at ATPu and the "regulatory gap"

In March 1994, an IPSN (Institut de protection et de sûreté nucléaire)[21] report established that seismic activity in the Cadarache region "*shows significant recurrence since the end of December 1993*".[22] The document stated moreover that a segment of the Durance seismic fault, a few kilometers from the Cadarache site, "*has experienced notable activity on several occasions, not only since the setting up of the Cadarache unit (in 1966-67 and in 1985-86 especially), but also historically: it was the seat of intense activity throughout a large part of the 19th century beginning with an event of intensity VII-VIII on 20 March 1812*".

This was determined thanks to the IRSN (Institut de radioprotection et de sûreté nucléaire) accelerogram network installed around the Durance fault, one of the most active seismic faults in France. The area around Cadarache has been the seat of destructive seismic disturbances (maximum intensities reach VIII on the MSK scale[23]) with a return period of around one per century. The last event of this type occurred in 1913.

On the basis of a Fundamental Safety Rule (RFS, Règle Fondamentale de Sûreté), dedicated to nuclear installations other than nuclear reactors[24], it became clear that the ATPu was not designed to resist a Safe Shutdown Earthquake (SSE)[25].

On 27 January 1995, the French safety authority informed CEA and COGEMA that ATPu had to be closed due to its non-conformity to anti-seismic norms and the impossibility for the facility to be modified to meet French seismic standards. The safety authority "*asks COGEMA to propose a plan for ATPu's future, including [...] a definitive and non-negotiable closure date for the facility, just after the year 2000*"[26].

After two follow-up letters from the safety authority[27], a first deadline was fixed for the 18 September 1996, but CEA and COGEMA did not even react. In a letter, dated 22 October 1997, the chairman of the safety authority André-Claude Lacoste informed CEA and COGEMA that "*this situation is not acceptable*", and he demanded to receive "*as soon as possible the plan taken into account for ATPu's future, and [...] a closing date of this facility*"[28]. On 11 December 1997, CEA and COGEMA answered that a project of a containment superstructure designed for a seismic event was under

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20 See our Briefing and its annexes on the Cadarache ATPu at: http://www.wise-paris.org/english/ournews/year_2000/ournews000719.html

21 In 2002, IPSN and the Radiation Protection Office OPRI (Office pour la protection contre les rayonnements ionisants) merged into IRSN (Institut de radioprotection et de sûreté nucléaire)

22 IPSN, "Technical note SERGD 94/13", 1994.

23 Medvedev-Sponheuer-Karnik scale (1964), which classifies earthquakes in function of their observed impacts. This is the scale used in France to measure seismic intensities.

24 RFS I.1.c, in Ministries of Economy and of Environment, "*Sûreté nucléaire en France - Législation et réglementation*", Les éditions des Journaux officiels, 1999.

25 The SSE is the design basis seism for a given facility. It is based on the concept of the Maximum Historically Probable Earthquake, defined as the maximum earthquake that is likely to happen over a period of time comparable to the "historical period" of about 1,000 years. The intensity of this seismic event increased by one unit on the MSK scale is used as the SSE intensity to determine the design basis of the facility.

26 DSIN, "*Compte rendu de la réunion du 27 janvier 1995*", letter DSIN/GRE/SD1/n°134/95, 28 March 1995.

27 DSIN, Letter DSIN/FAR/SD1/n°11684/95, 9 June 1995 and DSIN, Letter DSIN/GRE/SD1/n°101/96, 18 June 1996.

28 DSIN, Letter DSIN/FAR/SD1/n°11708/97, 22 October 1997.

consideration, but that they needed a few years before deciding to really build it or not. They added that "*from an industrial point of view, it is highly desirable, during the first decade of 2000, to profit from the significant modernization investments that were consented to since 1991 [...].*

Moreover, ATPu is used today to recycle into MOX fuel the German plutonium separated at the La Hague facility; for technical reasons, no other facility is at the present time able to serve such a mission. In the future, only MELOX, whose capacity will be raised to about 250 t/a of MOX fuel production, will be likely to guarantee such fabrication. Under these conditions, a hypothetical stop of ATPu cannot industrially be considered before the MELOX facility has undergone the evolution described above."[29]

"*Blackmailing"*, scribbled an official of the safety authority in the margin, in front of the last paragraph of the COGEMA letter... Although the authority put pressure on the operators, announcing it was ready to make authoritative decisions, CEA and COGEMA waited until July 2000 to answer and agreed to say that no technical solution was likely to be adopted to avoid the closure. After this point, the operator's strategy was to wait for a decision on MELOX public inquiry before deciding anything concerning the future of ATPu. The operators succeeded in protecting their commercial interests, in spite of significant safety concerns issued by the national nuclear safety authority.

The industrial strategy has finally been accepted, and even adopted, by the government. In October 2002, announcing the public inquiry into the extension project for the MELOX facility at Marcoule, the Ministries of Ecology and Industry stated that "*the purpose of this extension is to transfer to Marcoule the production of Cadarache facility, which has to be stopped soon*"[30]. Consequently, in January 2003, AREVA/COGEMA announced that the commercial operation of ATPu will be halted on 31 July 2003. Before the regulatory closure can be achieved, the operator is required to submit to the safety authority a safety report explaining the possible ways to close the facility. As of the end of February 2003, this report still had not been delivered and no further information is yet available about it. If the safety authority agrees with one of the suggested schemes, a decree has to be published, authorizing the facility to empty radioactive and nuclear materials. For ATPu, the regulatory closure will probably not take place before several years. And in spite of various announcements, the regulatory procedure has not begun yet.

While a decision to manufacture LTAs at ATPu is still possible, the fabrication will not start well after the 31 July 2003 closure deadline. While LTA fabrication could be considered as research production, and not fall under commercial fabrication, it would be difficult to explain to the French public that the Cadarache site is too dangerous for commercial MOX production for European use but not for handling of U.S. weapons-grade plutonium and its fabrication into MOX LTAs.

The French plutonium industry is generally covered with a veil of secrecy and information about the plutonium system is gained mainly from the pressure of "affairs" or accidents. Although the decision of the Belgian government to postpone its decision is public, no information is available on the French government side. Generally, information on plutonium management is hardly public and the "fait accompli" has become a management policy scheme.

Moreover, the blurry regulatory background of ATPu allows the avoidance of any public involvement in the LTA fabrication decision. A simple "exceptional license" signed by the French safety authority would be sufficient to apply LTAs fabrication at Cadarache, as soon as the French government, with no need of any public consultation, would have given its green light to proceed. However, so far, there is no indication of a French government intervention.

[29] COGEMA, Letter DIR/CSN 97/932, 11 December 1997.

[30] Ministry of Environment, *"Public inquiry request related to the request of COGEMA to extend the site of Marcoule"*, Press release, 23 October 2002.

3.B Quality, security and safety concerns

3.B.1 Weaknesses of the MIMAS fabrication process

Both ATPu and P0 plants apply a MOX fabrication process developed at the Belgian plant called Micronized Master Blend or MIMAS. Hereunder is a short description of the process:

Receipt of transport casks of plutonium and uranium powders, extraction of nuclear materials, identification, weighing and insertion in the process lines

- unirradiated plutonium has to conform with Pu-240 and Am-241 regulatory limits, depending on the plant authorization (for example more than 17% Pu-240 and less than 3% Am-241 for MELOX)
- depleted uranium used contains around 0.25% of uranium-235
- handling of powders in glove boxes

Master blend, i.e. mixing of plutonium and uranium powders to which crushed MOX scraps can be added

- plutonium is extracted from transport boxes at this step of the process
- master blend contains 30% plutonium
- scraps have to be crushed, analyzed and dosed before mixing

Homogenization and micronization of the master blend in a dry ball mill

- particle size becomes less than 15 µm[31] for an initial granularity of around 80 µm[32]
- milling lasts around 90 minutes, the dry ball mill operates around 4 hours a day at MELOX
- micronization is applicable only for around 70% of the produced scraps (because of its low reactivity regard to sintering, which makes it difficult to recycle)[33]

Final blend, i.e. addition of uranium powder to the micronized master blend, then homogenization

- added uranium powder is not first homogenized
- final blend reflects plutonium enrichment of the MOX fuel
- final blend is homogenized in a mixer (at MELOX 650kg of capacity[34])
- additives are added to facilitate pressing and sintering of the pellets by adjusting porosity

Pelletizing (pressing), sintering (in furnace) and rectification (grinding) to fabricate MOX pellets

- pellets are usually 15mm high with a diameter of 8.2mm for EDF fuel, with a density of $10.4 g/cm^3$
- pelletizing press delivers a 5,000 bars pressure[35]
- sintering, literally "baking" of the ceramic, takes place at 1,700°C during many hours, under a controlled atmosphere (argon, water vapor and hydrogen in excess)[36]
- rectification with a rotating grinder gives the target diameter to the pellets with a tolerance of ± 12 µm[37]

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31 G. Moneyron, *« Technologie et fabrication du combustible à base d'uranium »*, FBFC, *Techniques de l'Ingénieur*, August 1990

32 M.P Brossard, F. Drain, G. Bertolotti (SGN), L. Gaiffe (COGEMA), *« Continous Plutonium Conversion : French Engineering and Plant Operating Experience »*, Aiche 2000, 5-8 March 2000, Atlanta, US

33 R. Liberge, M. H. Mouliney (SGN), S. Masson (COGEMA), J.C. Thieblemont (CEA), *« The French Experience in Dry Milling of Nuclear Ceramic Powders »*, WM'99, 28 February-4 March 1999, Tucson, Arizona, US

34 D. Hugelmann, *« MOX Industrial Production: The MELOX Challenge »*, COGEMA, ICEM'99, 26-30 September 1999, Nagoya, Japan

35 P. Pradel, *« MOX Recycling in France, Current State and Prospects »*, COGEMA, TOPFUEL'97, 9-11 June 1997, Manchester, UK

36 J.L. Nigon, G. Le Bastard, *« Fabrication des combustibles au plutonium »*, COGEMA, *Techniques de l'Ingénieur*, October 2002

37 J.L. Nigon, op. cit.

Quality control

- control comprises a dimensional control, a density control, a visual examination and sampling for further controls in laboratory
- at this step only, non-conforming pellets are rejected

Rod fabrication and assembling

- storage in glove boxes allow to regulate the pellet flux
- rods are controlled by a radiography and a measure of their sealing

There is very little public information regarding the quality analysis of the MIMAS process. The apparent flux of scraps generated by the MELOX plant, probably more than the 46 tHM of MELOX scraps stored at the La Hague facility as of the end of 2001, give a global figure of more than 8% of apparent scraps flux over the operation period from 1996 to 2001. This figure is a mean calculation and does not reflect the high levels of scraps generated in the 3 first years of operation, probably around 15%, down to around 3% in 2001.

No public information is available on internal recycling of scraps, but figures above indicate that production of non-conforming pellets would have been very high in the first years of operation, probably as high as 30%. Refining of the MIMAS process in the first years of operation allowed COGEMA to gradually lower the scraps level.

Regarding available information, it is unlikely that MELOX is able to achieve a 0% rate of apparent scraps flux, but could reduce it probably to about 1 %. Moreover, this refining of the process could only be achieved during highly standardized production, where the entire annual production consists of only one type of fuel design. It is noteworthy that G. Lebastard, Director of COGEMA's fuel business unit, declared in December 2002, that changes in the fuel design produced at MELOX (because of the transfer of ATPu's production to MELOX) would probably rise the scraps level of the plant[38]. This indicates more generally that the MIMAS process quality level is firstly adapted to a uniform production, and that changes in the design of the MOX fuels produced, are likely to entail quality problems.

This problem was confirmed with the quality-control scandals, which hit both BNFL in 1999 and Belgonucleaire in 2000. Analysis carried out on MOX fuel produced by Belgonucléaire for the Japanese utility TEPCO revealed that irregularities could be found with regard to the pellet diameter distribution on some MOX batches, possibly hiding data falsification or revealing the poverty of the quality-control in general[39].

Moreover, its seems there could be some problems of homogeneity of the MOX produced with the MIMAS process. In fact, analysis has shown that in some parts of the MOX pellets, areas could be found with composition departing from the master blend specification, i.e. with plutonium hot spots involving enrichment levels significantly higher than the design basis. This lack of homogeneity could potentially have an impact on MOX management in reactor cores with regard to reactivity levels.

The problems mentioned above with the MIMAS process will also be of concern in operation of the U.S. MOX plant at the Savannah River Site and must be thoroughly reviewed by the U.S. Nuclear Regulatory Commission during both the construction authorization and operating license phases.

3.B.2 Proliferation and safety concerns relative to the manipulation of weapons-grade plutonium

The roughly 150 kg of weapons-grade plutonium oxide that would be shipped from the U.S. to Europe in case of the realization of the Eurofab option raise significant security concerns. Because the weapons-grade plutonium is not planned to be down-blended before shipping, it presents a very particular interest for any entity looking to acquire plutonium for a nuclear explosive or radiation

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38 NuclearFuel n°26, op.cit.

39 Green Action, *"Analysis Reveals Belgonucleaire's MOX Quality Control Data Highly Suspicious of Being Manipulated"*, 16 January 2001

dispersal device. The question is therefore how the material will be secured during its transport from the U.S., through France or Belgium, and back to the U.S.

The quantities of plutonium to be shipped are sufficient to produce 15-20 nuclear devices or more, but under procedures currently used could be shipped through France or Belgium with only one truck carrying 10 transport containers of 15 kg of capacity each. The COGEMA Logistics containers, called FS47, are the ones used to transport all plutonium separated at La Hague during reprocessing, to the ATPu, P0 and MELOX.

Around 90 transports of plutonium under powder form took place in France in 2001.[40] Considering the huge number of transports made every year, transportation of separated plutonium has become a kind of routine operation even if veiled by secrecy. In February 2003, Greenpeace demonstrated that few determined people could observe the plutonium transports in order to plan a significant action on one of them[41]. As a result, 25 people blocked a plutonium truck in a previously chosen spot for more than three hours. Moreover, the location where the action took place was in an urban area, which raises additional environmental and health concerns in the case of a direct attack against such a transport. This action illustrated that, even if plutonium transports in France and Belgium are allegedly organized so that the surrounding secrecy prevents actions against them, the security of such transports can no longer be guaranteed. Particularly given increased concern about security, the Greenpeace action profoundly underscores the nuclear proliferation risk presented by both plutonium shipments and the entire French reprocessing and MOX industry for which such transports are carried out.

The Greenpeace action disturbed the plutonium transports routine for roughly three weeks after which procedures were slightly modified. For example, trucks' cabins and platforms were exchanged to avoid easy identification by serial numbers. Now plutonium shipments are carried out in one day instead of two formerly, and sometimes two trucks with two different routes are dedicated for one plutonium transport.

While the Eurofab plan raises security and proliferation concerns, it also may have an impact on the general safety of the operations to be conducted to fabricate LTAs. Although the weakness of ATPu with regard to seismic risk cannot be neglected, the isotopic composition of the plutonium to be fabricated into MOX could have an impact on the criticality risk but also doses to workers, and, in case of an accident, doses to the public.

If the project to fabricate MOX with plutonium of high Pu-239 content in a plant that does not meet current French safety standards can be considered to be at least highly surprising, the fact that this material presents a higher criticality sensitivity could turn the Eurofab plan into a significant threat. Transport casks and fabrication lines, even if they have demonstrated the ability to handle materials with high plutonium content, have never demonstrated that they could handle such reactive materials.

Severe accidents during transport or fabrication processes are likely to change the geometry of the weapons-grade plutonium by reaching high compaction levels, and therefore could initiate an uncontrolled chain reaction. Moreover, in accidental conditions or following a terrorist attack[42], estimations have shown that a sufficient fraction of the plutonium content could be released, resulting in a high impact tens of kilometers down wind from the accident point. The potential consequences of such events should be thoroughly assessed before any decision on the future of the Eurofab plan is taken.

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[40] More information on plutonium transports (report in French only):
WISE-Paris, *"Hundreds of plutonium transports in France: a WISE-Paris report unveils this high risk activity"*, 21 February 2003 (http://www.wise-paris.org/english/ournews/year_2003/ournews030224.html)

[41] See: http://www.stop-plutonium.org

[42] For example terrorist attacks by plane on fabrication plants, and heavy weapon attacks on transport casks

4. Conclusion

The international plutonium industry is in decline. The traditional foreign clients of the two main providers of reprocessing services in France and the UK are not renewing decade old contracts. The fast breeder reactor technology, that was supposed to make use of the plutonium, has been abandoned by all of the Western nuclear countries. As a consequence, and because separation of plutonium has been ongoing in spite of the failure of the fast breeder reactors, there are vast stocks of separated plutonium. The use of plutonium in the form of mixed oxide uranium-plutonium or MOX fuel has been promoted, mainly by the plutonium industry itself. However, a series of quality-control scandals, especially in the UK and Japan, as well as the high costs compared to the uranium fuel option, have thrown the plutonium strategy into disarray.

On the other hand, the U.S. Government has decided to dispose of 34 MT of weapons grade plutonium in the form of MOX fuel, though the program still faces regulatory, technical and financial hurdles. Due to U.S. inexperience, the European plutonium industry has been called on to help with the development of an entire plutonium fuel system in the U.S.. In order to accelerate the process, impacted by frequent and significant delays, the U.S. Government has decided to ask the French and Belgian Governments for the possibility to get MOX lead test assemblies (LTAs) fabricated in COGEMA's ATPu facility in Cadarache, France or in the P0 facility in Dessel, Belgium – the so-called Eurofab option.

While the U.S. Department of Energy and COGEMA and Belgonucléaire continue to communicate about the Eurofab option, the public has been left out of this discussion. Given that the public will be placed at risk during transport and fabrication operations, particularly at the seismically-unsafe Cadarache plant, the plans being discussed behind closed doors should urgently be publicly presented and analyzed. Further, the flimsy regulatory framework of the 40 year old Cadarache and Dessel facilities does not guarantee an appropriate licensing procedure.

DOE's presentation to the French and Belgian Governments that it would undertake preparation of an Environmental Impact Statement (EIS) on the LTA program should be honored and plans for the sea shipment of weapons plutonium from the U.S. to Europe should be revealed and publicly discussed.
In hand with this, the DOE should take immediate steps to insure that the public has a role in the overall decision-making process associated with this program, along with fully revealing its overall costs.

That the French Government would permit the U.S. Government to enter into a MOX fabrication contract even after commercial operation has ceased at Cadarache at the end of July 2003 is a highly-charged political issue which could have serious environmental and public health consequences.

Thus, the following question is urgently awaiting an answer: If Cadarache is too unsafe for fabrication of French or German MOX made from reactor-grade plutonium then why is it safe enough for fabrication of weapons-grade MOX for the United States?