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# International Seminar
# on PWR Technology and operation

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# FRENCH NUCLEAR ORGANIZATION

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# FRENCH NUCLEAR ORGANIZATION

## 1 - HISTORICAL BACKGROUND

Nuclear energy is an old activity in France since the first international patents related to nuclear power generation were taken in May 1939 by F. Joliot-Curie and his team. The French nuclear activities began in fact in 1945 when the French Atomic Energy Commission **(Commissariat à l'Energie Atomique, CEA)** was created. At that time this research organism coped with all the technical problems linked to nuclear construction. The first research reactor, ZOE, was operated in 1948, and the first nuclear electricity was produced in 1956, when the graphite-gas-cooled reactor $G_1$ was connected to the grid.

The CEA implemented all the research facilities, like experimental reactors and hot cells, and carried out the technological studies required by the development of the graphite-gas cooled reactors. Six reactors of this type, totalizing 2 300 MWe, were commissioned between 1963 and 1972 in cooperation with **Electricité de France (EDF)**, the state-owned utility.

In parallel, the PWR technology was introduced in France in 1958 when FRAMATOME was created to design PWRs under Westinghouse licence,and also when the CEA developed at that time the NSSS for nuclear submarines.

The first PWR order was received in 1961 for the 300 MWe Chooz nuclear power station, the second in 1967 for the 870 MWe Tihange power station shared with Belgium..

As far as the nuclear fuel cycle is concerned, the CEA was in charge of ensuring the independence of the nation in the nuclear field, and, step by step, has acquired all the necessary expertise from ore to waste . Reprocessing was the option chosen for the back-end of the fuel cycle, for two reasons : it was the best way to manage the radioactive wastes, and plutonium recovering was considered to be necessary to ensure the nuclear fuel supply of fast breeder reactors in the future.

In 1976, the fuel cycle industrial activities of the CEA were transferred to **COGEMA (Compagnie Générale des Matières Nucléaires)**, a wholly-owned subsidiary of the CEA, through the holding **CEA-Industrie.**

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From 1970 to 1973 EDF ordered 6 x 900 MWe PWR units which were expected to be more profitable than GCRs. In 1972 **FRAMATOME** acquired Le Creusot and Chalon factories, and became manufacturer as well as designer.

So, in 1974, when the first oil shock entailed the ordering of the first EDF multiunit contract, covering sixteen 900 MWe PWR units, the main components of the French nuclear organization already existed.

## 2 - THE FRENCH ORGANISATION FOR NUCLEAR INDUSTRY

The French nuclear organization is characterized by two main features : the small number of firms involved, and the role of the Government. These features are very specific regarding the nuclear organizations observed in other countries. They can be considered as a major reason of the success of our nuclear program.

### 2-1 - EDF, the national utility

Only one utility is involved, and moreover, it is the largest utility in the world. It was created in 1946 as a state-owned company responsible for the main part of power generation and electricity distribution in France, and for the whole of transmission, imports and exports of electricity.

EDF is supervised by the Ministry of Industry and the Ministry of the Economy, Finance and Budget. Investment is financed from EDF's own resources and by public borrowing, subject to government approval.

Regarding conventional and nuclear construction and operation, EDF is in charge of several tasks.

**Engineering and construction** are covered by the equipement division (Direction de l'Equipement). First, this division is concerned with preliminary basic studies for new projects and the technical specifications of major components ; in such a way, EDF is in a position for orienting technical choices or ordering R and D studies. Second, this division does its own architect-engineering and project management for site preparation and balance of plant. Third, it is responsible for quality control at manufacturers' works. The staff of this division reached 5 000 in the mid-80s when engineering and building activities were the highest.

**Operation and maintenance** of nuclear power stations as well as coal or gas fired ones is the responsability of a service within the operation and transmission division (Direction de la Production et du Transport).

This service (Service de la Production Thermique, SPT) is also in charge of nuclear safety. But maintenance is now one of its main tasks. One body, set up within SPT, provides repair and maintenance assistance to power plants in real time at the operational level ;it is also concerned with spare parts supply, control of nationwide modification program, provision of special tools and equipment, problem solving and reduction of outage times, and sharing of information between plants. There is also within SPT a group of expert maintenance engineers charged with formulating overall maintenance policy.

**Nuclear fuel management** is covered by the Service des Combustibles (SC) within the Direction de la Production et du Transport. It is in charge with fuel requirement forecasting, the elaboration of supplying contracts with suppliers, mainlly with COGEMA, and the control of fuel quality ; it is also responsible for contracting with ANDRA for the spent fuel and waste management.

EDF's organisation shows some particular features in comparison with most utilities : EDF is in a position to manage all the aspects of implementing and operating a large nuclear power system, and to propose adequate solutions to cope with the constraints and uncertainties of the future.

### 2-2 - FRAMATOME, the nuclear island manufacturer

**FRAMATOME** provides a complete range of PWR services from design through manufacture to commisioning and maintenance. Most components and systems, like reactor vessel, reactor internals, steam generator, pressurizer, and in-core instrumentation, are produced in its own factories using advanced production-line. It provides transport, erection, testing and start-up services, with all associated quality assurance and quality control services.

Through **FRAGEMA**, a FRAMATOME subsidiary (owned 50 : 50 with COGEMA), this manufacturer supplies fuel assemblies for first core and reloads as well as control rods, burnable poison rods.

Maintenance and off-line servicing of PWRs is an increasing activity of FRAMATOME. In this field, it can be mentioned devices to reduce worker exposure, non-destructive testing, steam generator replacement, and personnel training. For this purpose, FRAMATOME is part owner of several specialist maintenance companies in France, like **STMI (Société des Techniques en Milieu Ionisant)**, and in foreign countries, in Spain and United States.

The shareholders of FRAMATOME are the ALSTHOM group (44 per cent), CEA-Industrie (36 per cent), the bank CREDIT LYONNAIS (5 per cent), EDF (10 per cent), and the company's employees (5 per cent).

**2-3 - GEC-ALSTHOM the manufacturer of turbine-generators and electrical equipment**

**GEC-ALSTHOM**, part of the group ALCATEL-ALSTHOM, is the well-known international firm in the field of energy and transportation. As far as PWRs are concerned, this firm is the only French manufacturer of turbine-generators, electrical equipment, and other equipment of conventional island like heat exchangers and condensers, and also the related plant instrumentation and control systems.

GEC-ALSTHOM's experience and R & D facilities have enabled it to develop the Arabelle turbine-generator for the $N_4$ - PWR series, characterized by a higher output than the earlier models. This company provides also the maintenance of conventional island with the related quality assurance and quality control services.

**2-4 - COGEMA, the fuel cycle supplier**

Policies implemented by successive governments over 40 years have produced a matrix of companies covering all aspects of the fuel cycle. Nowadays all these companies are owned, outright or in part, by COGEMA, the wholly-owned subsidiary of CEA-Industrie.

The role of **COGEMA** is essentiel to ensure the security of nuclear fuel supply, for all the steps of the fuel cycle.

So, in the **mining sector**, COGEMA has both mining operations in France, and shares in mining companies in Africa, in Canada and United States.

In the **conversion and enrichment sector**, COGEMA through **COMURHEX** performs uranium conversion for the gaseous diffusion enrichment plant of **EURODIF**, which is a multinational company (COGEMA 51.5 per cent, plus Italy, Spain and Belgium).

**Fuel fabrication** for PWRs is covered by **FBFC (Société Franco-Belge de Fabrication de Combustibles)**, shared between COGEMA and FRAMATOME ; the fabrication of fuel-rod tubing is provided by **ZIRCOTUBE**, owned by FRAMATOME.

**Reprocessing** of PWRs spent fuel is undertaken in the two La Hague plants. The first one $UP_2$ is devoted to EDF fuel and its current capacity of 400 t/y will be extended to 800 t/y ; the second one $UP_3$ (800 t/y) is in operation for reprocessing of LWRs fuel from foreign utilities. COGEMA operates these two plants, including the vitrification of high-level radioactive wastes. **SGN (Société Générale Nucléaire)**, a subsidiary of COGEMA, deals with the desing and engineering of reprocessing plants ; it is involved in the construction of the Rokkasho-mura reprocessing plant in Japan.

### 2-5 - ANDRA, the nuclear waste agency

Created in 1979 as a special agency within the CEA, **ANDRA (Agence Nationale pour la Gestion des Déchets)** is nowadays a state-owned organization apart from the CEA. Its task is to establish standards for waste management, to develop and manage disposal site. For example, ANDRA designed, and now operates the Aube Center repository for low-level wastes. In the near future, ANDRA will investigate four sites with different geological conditions suitable for a deep underground repository for medium and high level wastes.

### 2-6 - The CEA, the R and D organism

The CEA is responsible for R and D into both the civil and military applications of nuclear power. While the main thrust of its civil activities is towards new processes for future applications, it has continued to be closely involved in the industrial program longer than similar bodies in other countries.

The **CEA (French Atomic Energy Commission)** is under control of the French government. For its civil activities, it is funded by the Ministry of Industry and from its own resources resulting from research studies undertaken on behalf of nuclear industries and EDF. The total R and D expenditures concerning nuclear energy were broken down in 1991 as follows :

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|---|---|
| - reactors and fuel assemblies | 30 per cent |
| - fuel cycle | 43 per cent |
| - radiation protection and nuclear safety | 27 per cent |

In the definition and implementation of the R and D programs, there is close cooperation between the partners in the industry : CEA, EDF, FRAMATOME, COGEMA, ANDRA. As far as funding is concerned, the general idea is that the government pays for the long-term or medium-term research, and industry pays for the research it needs directly for the existing or under construction plants and facilities. With PWRs the objective is both to achieve reduced investment and operating costs in existing and new units (including life extension to 40 years or more), and to make plants still safer.

Two examples can be given in this field. The first one concerns a test loop which has been built for the study of thermal-hydraulic and vibration in the $N_4$ steam generators. The second one is related to another loop developed for studying thermal-hydraulic behaviour during small and medium breaks in the coolant system.

PWR fuel performances have been improved with the help of CEA R and D teams and their testing facilities (testing reactors, hot cells, laboratories) in cooperation with FRAMATOME and FRAGEMA. So, an advanced PWR fuel assembly, AFA, has been developed ; besides, the current 33,000 MWd/t burnup has been raised to 42,000 MWd/t and perhaps

more in the future, as envisaged with the new fuel assembly X1. Besides, MOX fuel has been developed. All these developments concern new fabrication process, irradiation tests and neutronic calculations.

Within the fuel cycle, the main research program is devoted to Atomic Vapour Laser Isotopic Separation (SILVA) which has been chosen to replace the gaseous diffusion used in the Eurodif plant.

Reprocessing technology for LWRs, MOX fuel and FBR fuel is expected to be improved in a new laboratory complex (Atalante) which must be in operation in the mid-90s. Particular attention will be given to the reduction of effluents and wastes in reprocessing.

A large research program, recently launched by the CEA, consists in separating the actinides (long life radioactive waste) from fission products during reprocessing ; the final objective is to transmute them into fission products by in-core irradiation either in PWRs or more likely in LMRs.

Safety activities within the CEA are covered by **IPSN (*Institut de Protection et de Sûreté Nucléaire*)**, the role of which will be precised later on in 3-2.

### 2-7 - *Favorable consequences* of the French nuclear organization

The small number of actors, a single manufacturer in each industrial field (boiler, electrical equipment, and fuel), a single and large utility, a large nuclear R and D organism, the choice of only one reactor technology (PWR), and, in a lesser extent, the choice of only one enrichment technology (gaseous diffusion), are the main reasons of the success of the French nuclear program.

This effective industrial structure presents many advantages. It facilitates the definition of clear tasks for all the actors and the setting-up of good links between them. It permits a rigorous policy of standardization, the benefits of which are too well-known to be presented here ; it is to be stressed upon that the very low nuclear generating cost in France mainly results from this policy. It permits also a good operating experience feedback to improve both the availability of the existing nuclear power system, and the design of the future projects.

A major consequence of the very good cooperation between EDF, FRAMATOME and the CEA, is the assimilation and mastery of PWR technolgy by French industry which has gradually improved NSSS design, so that in 1982 the FRAMATOME licensing agreement with WESTINGHOUSE was replaced by a high-level technical cooperation agreement. Recently, a new reactor model, the 1,450 MWe $N_4$, has been developed by FRAMATOME and is a wholly French design.

## 3 - THE ROLE OF GOVERNMENT AND PUBLIC AUTHORITIES

### 3-1 - State control over nuclear decision making

France has a long history of centralized state control and planning, especially in the energy sector which is condidered as a major concern due to the lack of its domestic energy resources. Successive governments have seen the nuclear program as an essential part of a clear economic and political strategy to secure energy independence and to improve the performance of the economy as a whole. Strategic considerations have maintained their influence on decision making much longer than in other countries with nuclear programs.

This explains that in the nuclear sector, as in other energy sectors (oil, gas and coal), the main companies, like EDF or COGEMA, are wholly state-owned ones although they are managed as private firms ; their general manager is appointed by the government, their strategy is supervised by the Ministry of Industry. Other companies are partly state-owned, like FRAMATOME through the shares of the CEA, EDF and CREDIT LYONNAIS, totalling 51 per cent..

. In order to reinforce its nuclear policy, the government brought about several times major changes in the structure of the industry. For instance, it convinced very recently PECHINEY to sell its nuclear activities both in the conversion sector and the fuel fabrication sector to COGEMA and FRAMATOME ; so, there are now only two nuclear suppliers in France, the structure of nuclear industry is clearer and more integrated.

At the very beginnings of the French nuclear program, as early as 1954 and up to 1979, an advisory comittee (C.C. PEON) used to be held upon request of the Ministry of Industry, to give the government advice upon the nuclear program expansion. It gathered all the Ministries involved, all the nuclear manufacturers and suppliers, EDF and the CEA, and delivered recommandations. Finally, orders concerning nuclear power plants as well as fuel cycle plants were submitted to government approval.

### 3-2 - Safety and licensing organization in France

Technical nuclear safety aims at prevention of accidents and limitation of their consequences ; it also includes technical provisions devoted to ensure normal operation of installations without excess radiation exposures of workers together with optimized radioactive waste production and management.

Basically, **responsabilities for technical nuclear safety** in France are as follows :

- public authority sets general safety goals,

- operators propose technical provisions to achieve those goals,

- public authority check those provisions to verify they are actually satisfying : this is safety analysis,

- operators implement approved provisions,

- public authority, through inspections, check installations to verify technical provisions are correctly implemented.

At last, parliamentaries, when they seek it useful, check the whole procedure for information purposes.

The public authority in charge of nuclear safety is **DSIN (Direction for the Safety of Nuclear Installations)** which is dependent on the Minister in charge of Industry and is also at the disposal of the Ministry in charge of Environment ; for all technical expertise works it relies on technical support of **IPSN (Institute for Nuclear Protection and Safety)** briefly described here after ; besides, in regions where nuclear installations are built, specialised nuclear divisions have been set up within the regional administration ; they also include inspectors who work together with the national ones. In case of an accident, DSIN, with IPSN support, gives technical advice to the Prime Minister, while the nuclear division in the concerned region gives advice to the Prefet.

The IPSN, which is part of the CEA, is in charge of the research, studies and technical work related to radioprotection and nuclear safety on behalf of the ministerial bodies and organisms involved in order to contribute to the definition of actions in these fields for further application by the department in charge.

Besides, the **SCPRI, Service Central de Protection contre les Rayonnements Ionisants (Central Service of Protection against Ionizing Radiations)** is the public authority for radiation protection : it is in charge of the dosimetry surveillance of workers exposed to ionizing radiation, and responsible for the monitoring of effluent releases and for the radioactive environment for the whole national territory.

The coordination of relevant administrative actions for all aspects of nuclear safety and protection is secured by the **Comité Interministériel pour la Sécurité Nucléaire (Interministerial Nuclear Safety Committee)**. The committee's general secretary has power to check that safety measures are being applied by the ministries and other bodies in the industry.

Regarding nuclear safety, the **licensing procedures** mainly include several steps :

- **public inquiry** on the environmental and local safety measures : a Déclaration d'Utilité Publique, DUP, is made for the site.

- **construction license** of the nuclear plant : a preliminary safety report is presented by the operator to Ministries in charge of Industry and Environment ; it describes main design features of the plant : IPSN carries out the analysis of the report, and, based on this analysis , a Group of experts, the "standing group", gives its advice to the Ministers who, then, issue a draft bill ; advices of CIINB (Interministerial Commission for Basic Nuclear Installations, composed of representatives of various Ministries) and of Ministry in charge of Health are requested : the construction license decree of the plant can then be issued.

- **operating license** of the nuclear plant : based on a provisional report of the operator, describing the plant as it has been realised, and based on the analysis of IPSN and on the advice of the standing group, an authorization is first given by Ministries in charge of Industry and Environment to start up the plant ; after the tests period, a final report presenting the results of those tests is issued by the operator, analysed by IPSN and results in an advice of the standing group : both Ministries can then give the final operation license ; this authorization must occur within a delay given in the construction license decree.

Besides, special procedures are set up for :

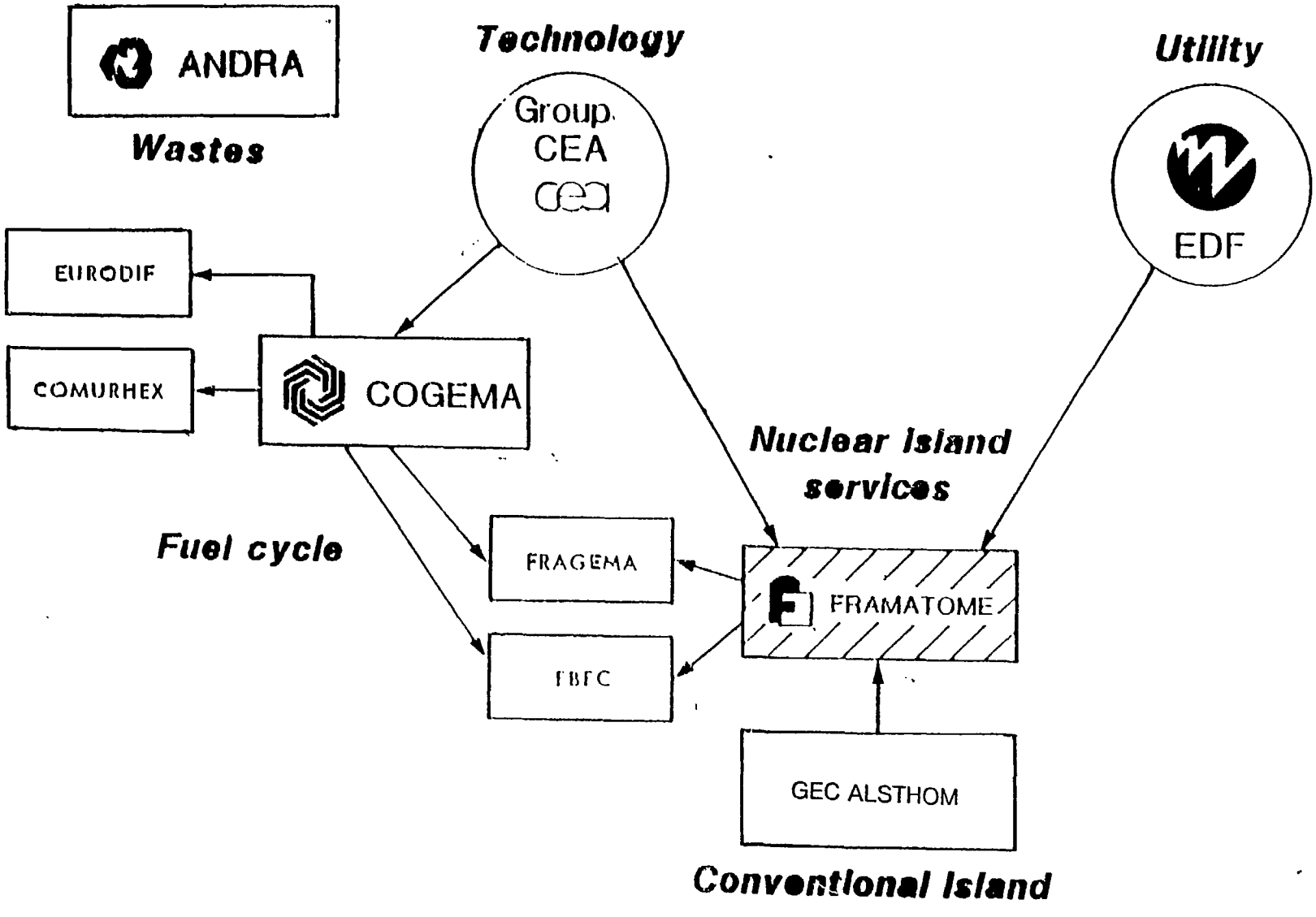
- licensing of the pressure vessel : this procedure, typical of French regulation, applies to every pressure vessel.

- licensing of radioactive liquid or gazeous effluent releases.

## 4 - CONCLUSION

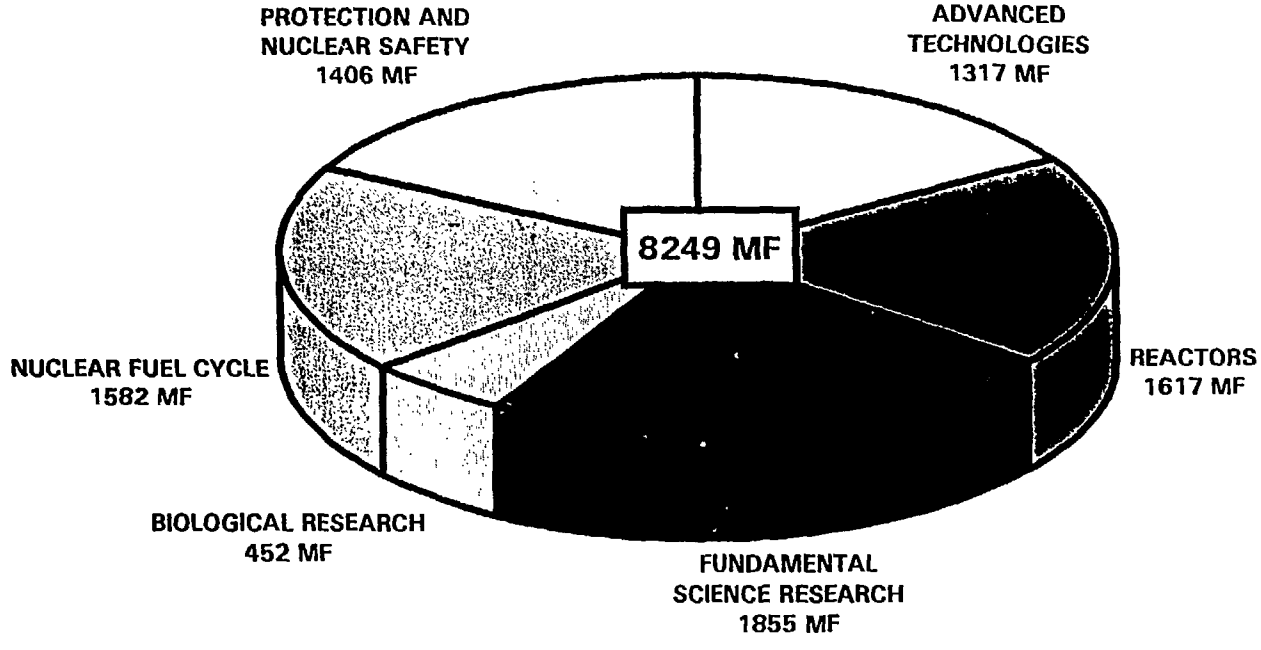
The French nuclear organization has proved to be effective for the way in which the various aspects, from finance to the training of engineers and technicians, have been integrated and co-ordinated between all the involved bodies of the industry and Public Authorities. This is all the more remarkable because most nuclear power plants and fuel cycle plants were implemented within around ten years.

It always must be reminded, when the technical and economic performances of the French nuclear program are presented, that a good organization is the prerequisite condition of such a success.



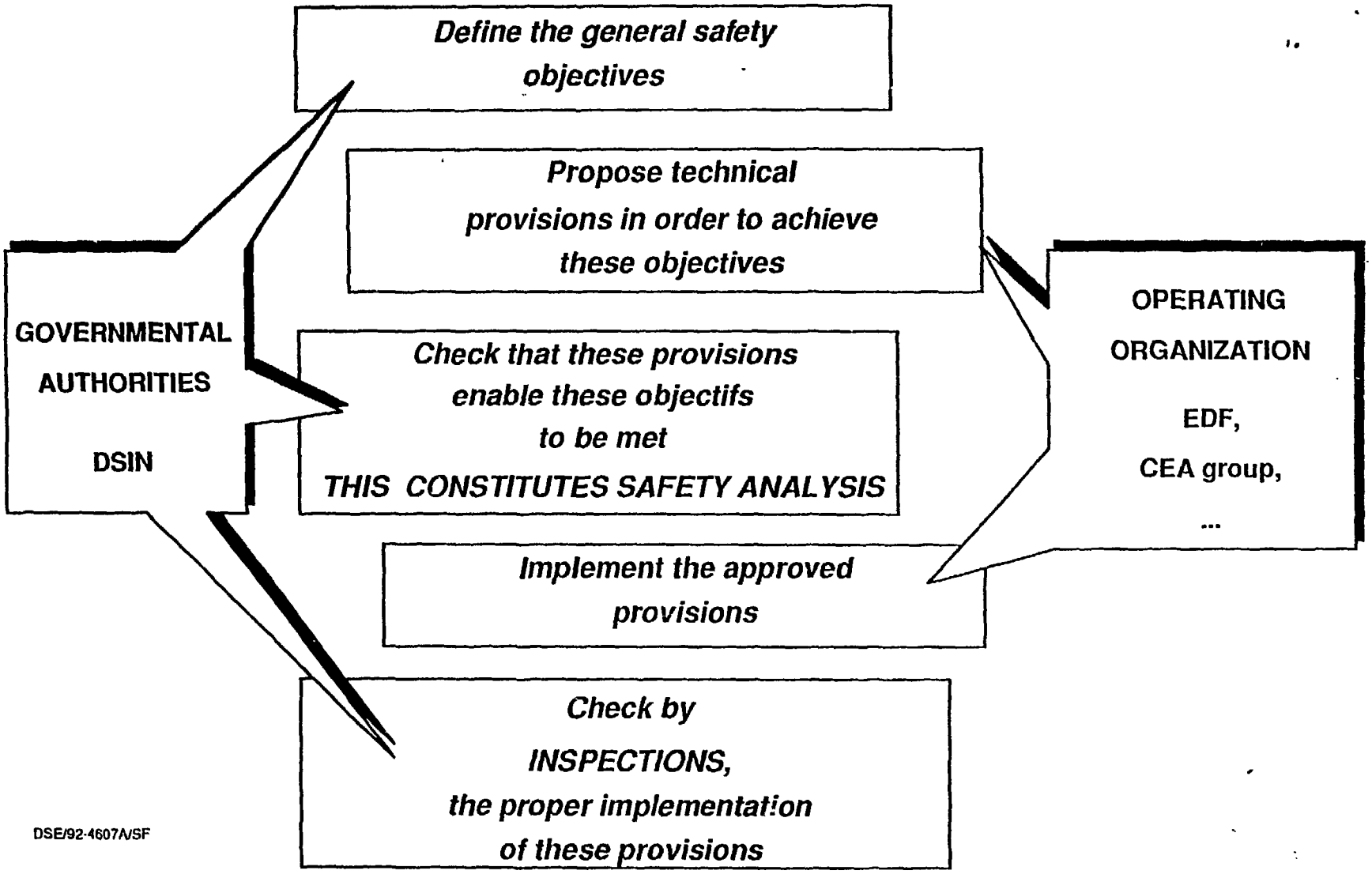

FRENCH NUCLEAR PROGRAM : MAIN ACTORS

# CEA CIVIL RESEARCH



# TECHNICAL NUCLEAR SAFETY

## Who is responsible ?

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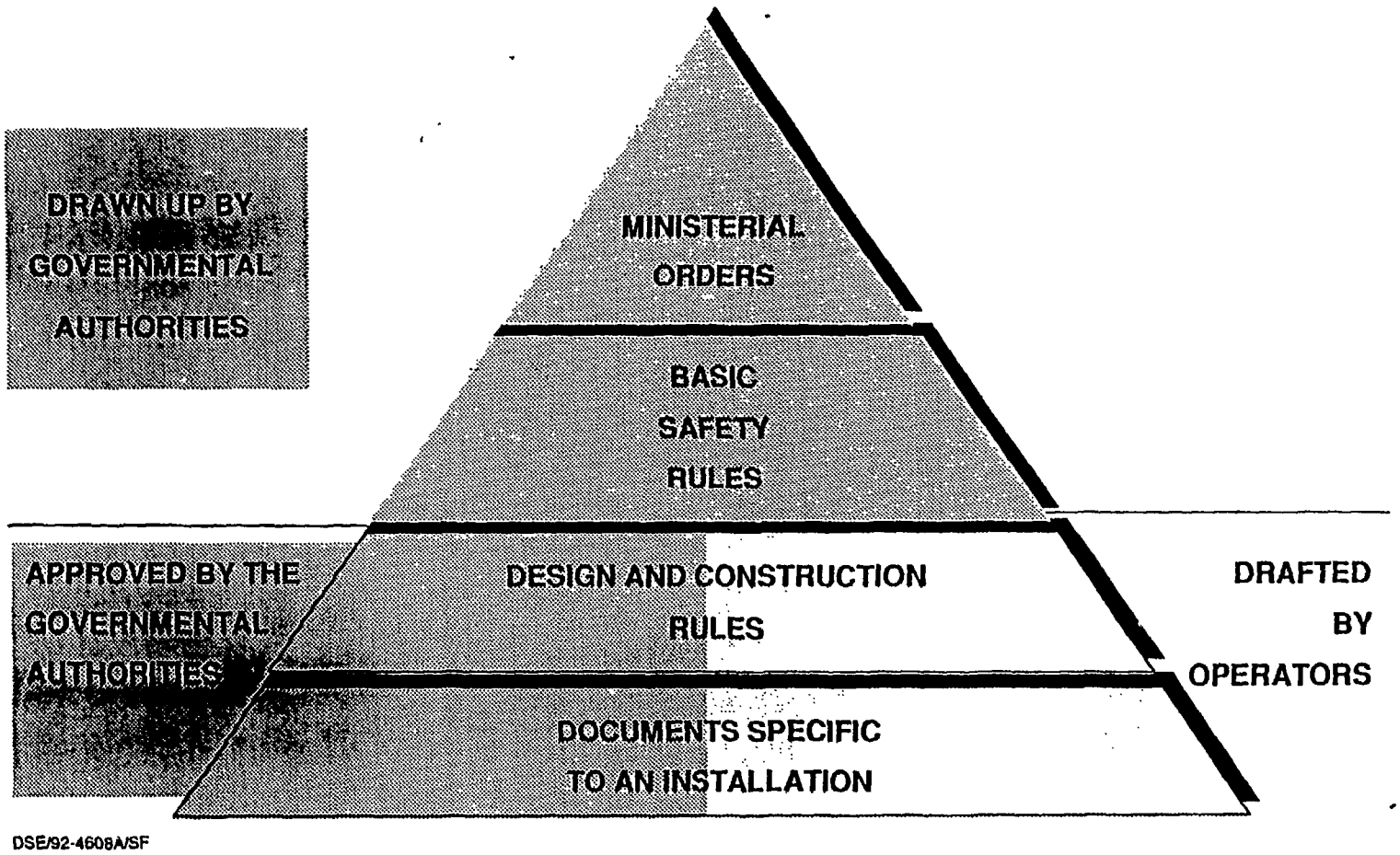
# THE REGULATORY PYRAMID

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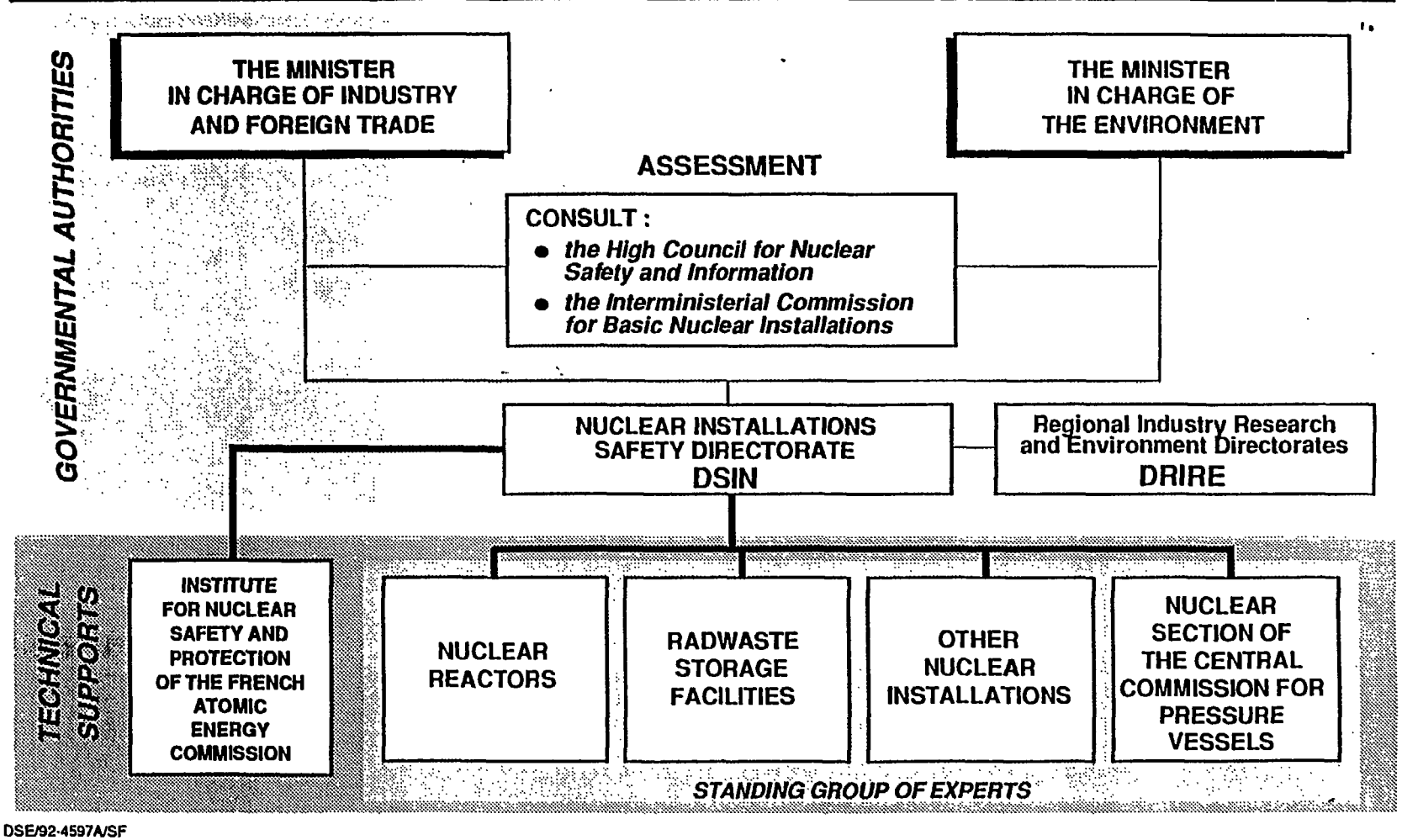
# TECHNICAL NUCLEAR SAFETY IN FRANCE

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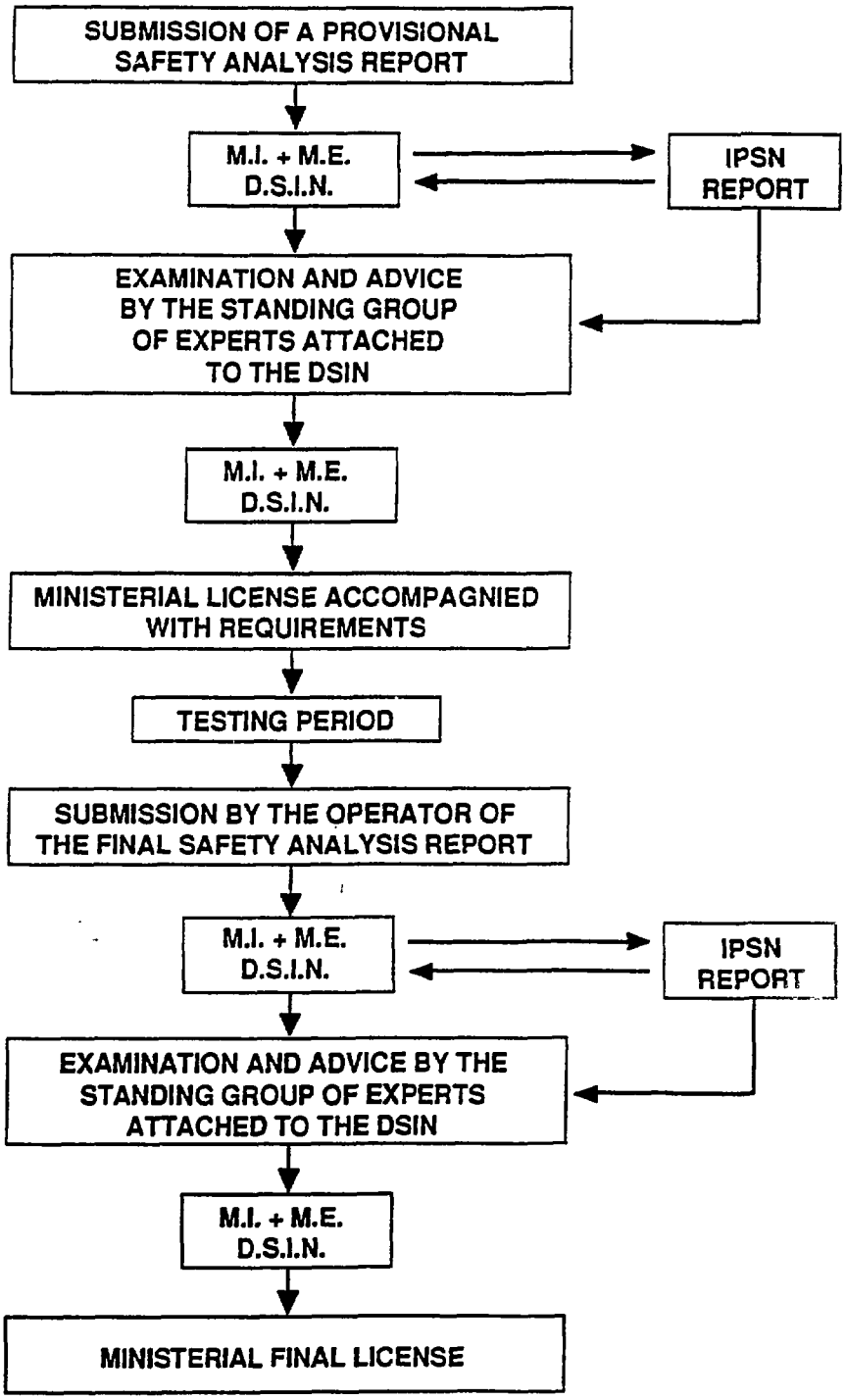
# *BASIC NUCLEAR INSTALLATION OPERATING LICENSE PROCEDURE*

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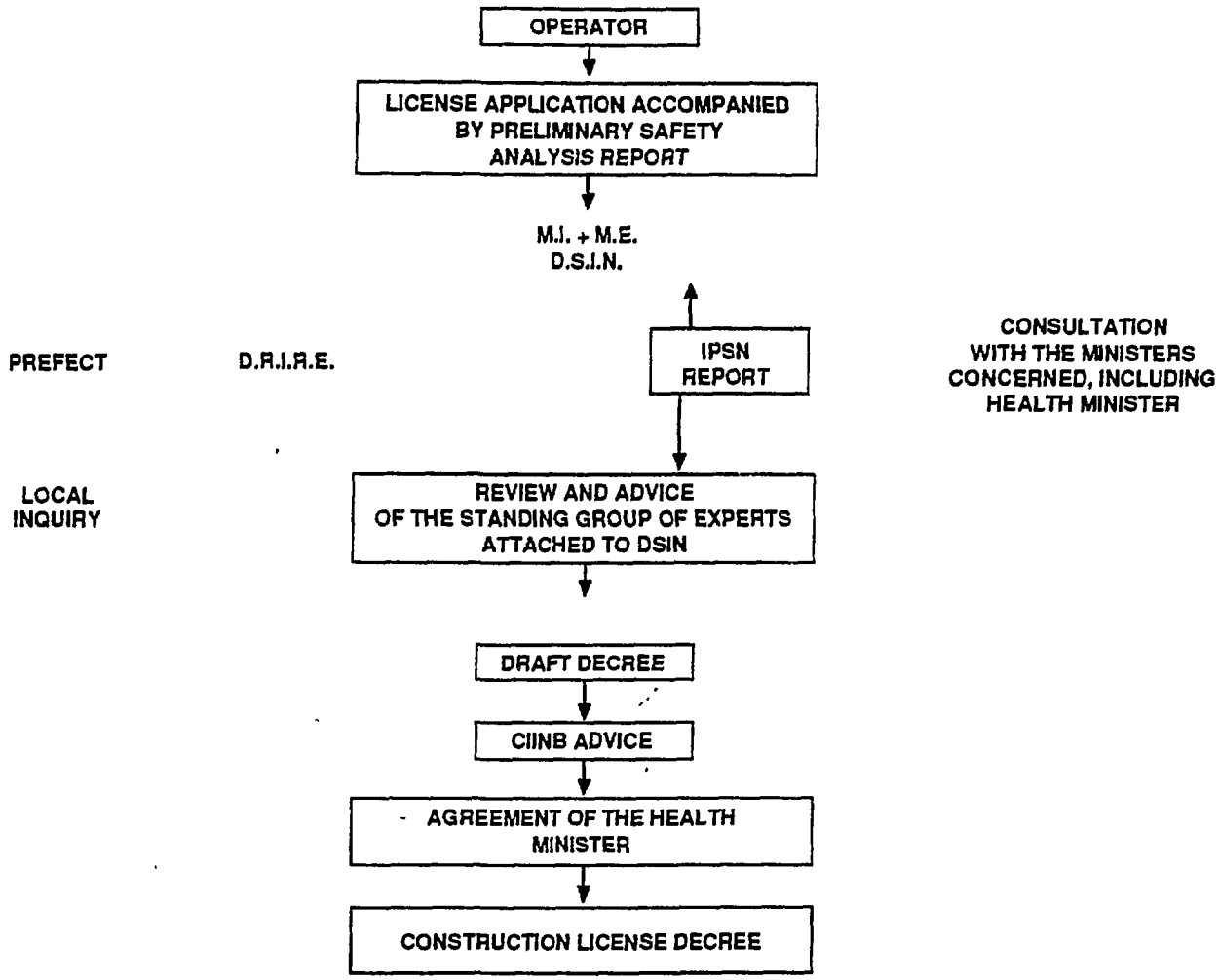
# BASIC NUCLEAR INSTALLATION CONSTRUCTION LICENSE PROCEDURE

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