資料第4－2－1号

講演メモ

FBRs : Why, When, How

フランス 原子力庁 原子炉局
バートランド バレ局長

The 4th Meeting of The Special Committee on Fast Breeder Reactors
May 8, 1997

FBRs : Why, When, How

A Presentation before the FBR Special Committe

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Co-Chairman, EJCC on FBR R&D

Co-Chairman, RFCC on FBR R&D

A Tale of Two Countries (1)

	FRANCE	JAPAN
Area (km^2)	**552 000**	**378 000**
Population (M ha)	**58**	**125**
GNP ($/cap)	**23 000**	**37 000**
Energy Consumption (Mtoe)	**230**	**425**
Prod/Cons (%)	**51**	**10**
Electricity Generation (TWh)	**460**	**960**
Nuclear Share (%)	**75**	**30**

A Tale of Two Countries (2)

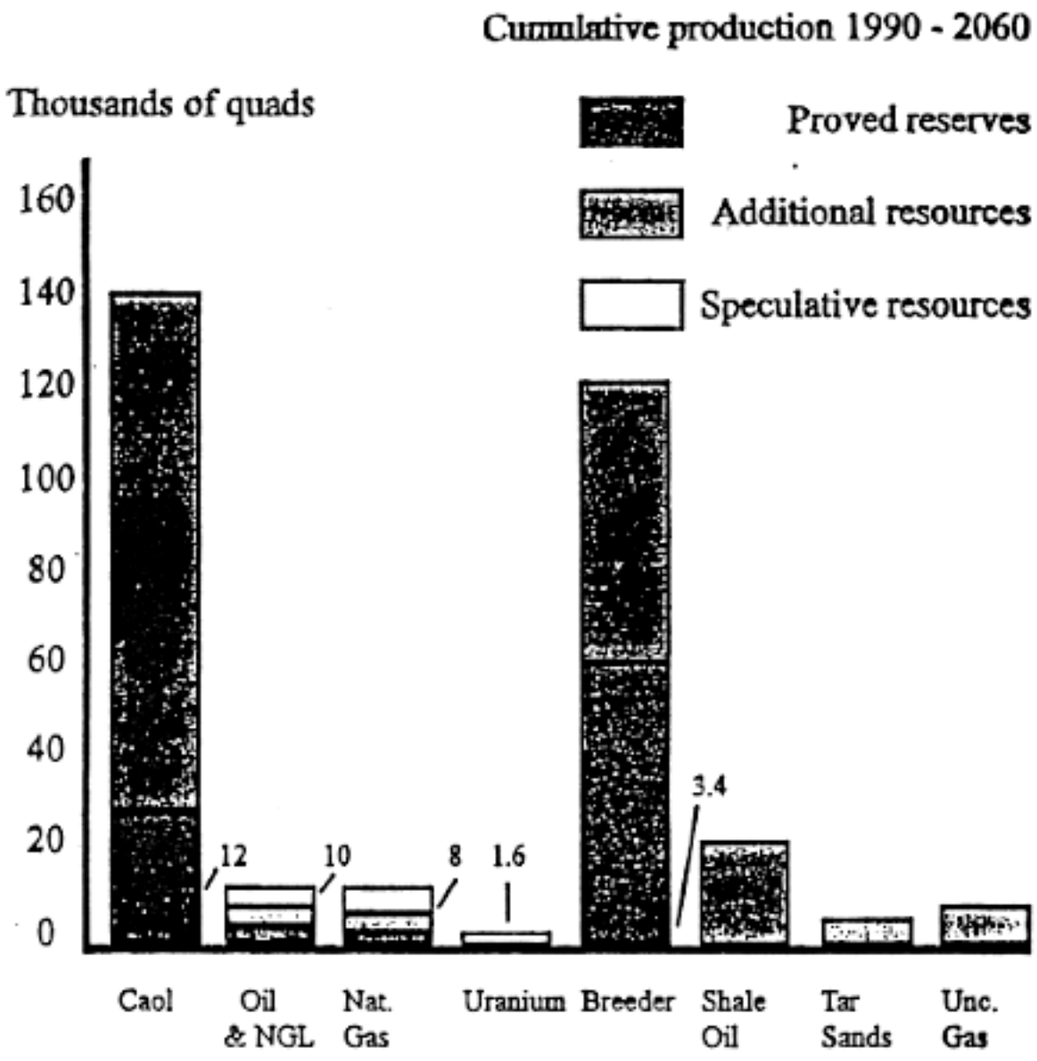
1995年

	FRANCE	JAPAN
Nuclear Elec Generation (TWh)	**377**	**288**
Installed Nuclear Power (Gwe)	**58**	**41**
# PWR	**54**	**22**
# BWR	**0**	**27**
# HWR	**0**	**1**
# FBR	**2**	**1**

(december 95 figures)

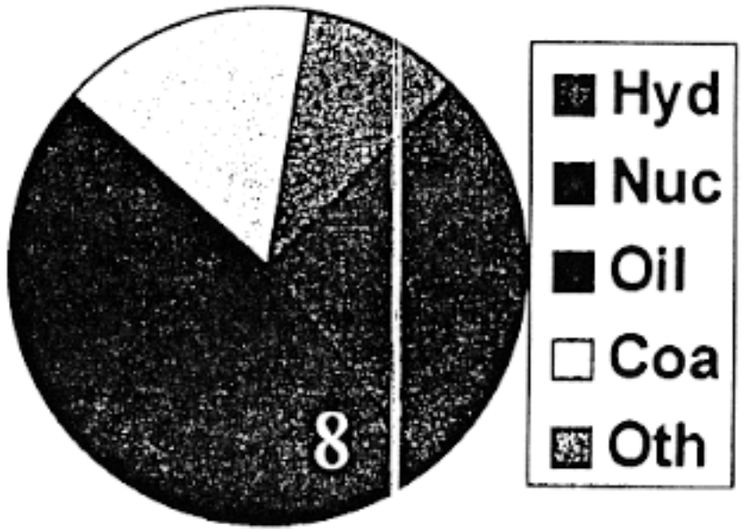
	Population		Mtoe	
	1990	2020	1990	2020
North America	276	326	2172	2353
Latin America	448	716	582	1451
OECD Europe	454	489	1442	1701
Central Europe	100	111	295	322
CIS	289	344	1372	1449
North Africa + ME	271	543	297	807
Subsahara Africa	502	1195	267	693
Japan + Aus/NZ	150	163	543	606
South Asia	1146	1938	449	1454
South-East Asia	1657	2265	1309	4530
TOTAL WORLD	5293	8090	8728	15366

Earth Energy Ressources

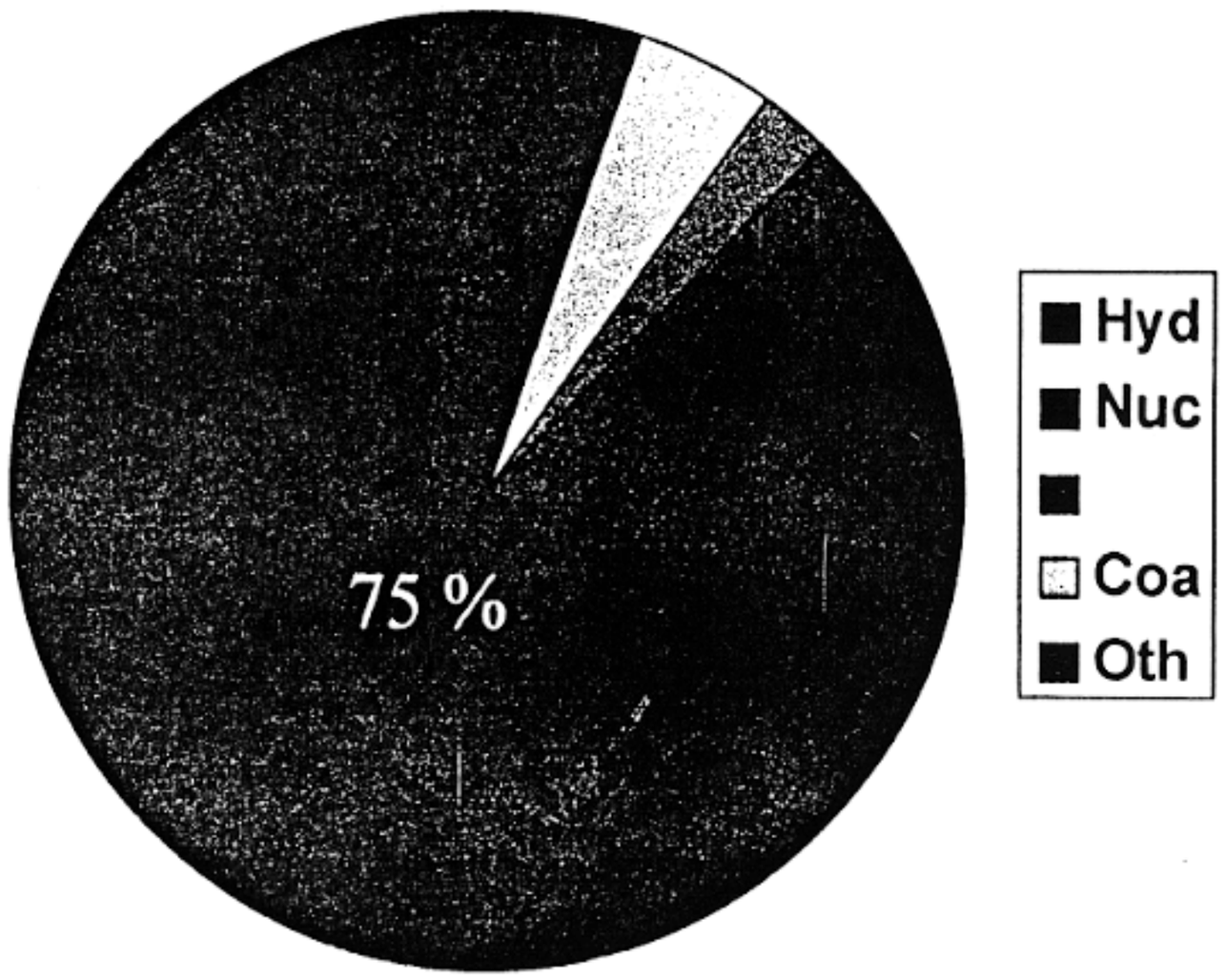


Source : US NAS

French Electricity Generation



1973 : 174 TWh



1995 : 471 TWh

FBR Developments in France

Rapsodie 24/40 Mwth 1967 - 1983 Loop

Phénix 250 Mwe 1973 - Pool

Superphénix 1200 Mwe 1885 - P

all Na cooled, $(U,Pu)O_2$ fueled

Plus design studies Phénix 450 (1974), Superphénix 2 (1976), 1500 Project (1982) EFR (1988 -1993-...)

Phénix Achievements

- **97 000 hours connected to the grid**
- **3 800 EFPD**
- **Complete fuel recycling from bred Pu**
- **Demonstrated Breeding Ratio 1.15**
- **144 000 MWd/t**
- **15 clad failures / 170 000 irr. pins**

Superphénix : part 1

1200 Mwe FNR plant, owned & operated by NERSA

(51% EdF, 33% ENEL, 16% other european)

- **1976 : Start of construction, at Creys-Malville**
- **7/9/1985 : First criticallity**
- **12/1986 : Full power operation**
- **4/1987 : Na leak (20t) at the *barillet* > 20 months**
- **1/1989 : Restart**
- **3/7/1990 : Shutdown for Na pollution (since 20/6)**

Superphénix : interlude

- **7/1990 to 6/1992 : Safety re-analysis. DSIN report dated 16/6 advises restart at 30% power, but decision to wait for Na fires reinforcements > creation canceled**

- **27/10/1992 : request for new creation.**

- **1993 : New public Enquiry (and 2ndary side revamp)**

- **18/1/1994 : DSIN recommands authorization**

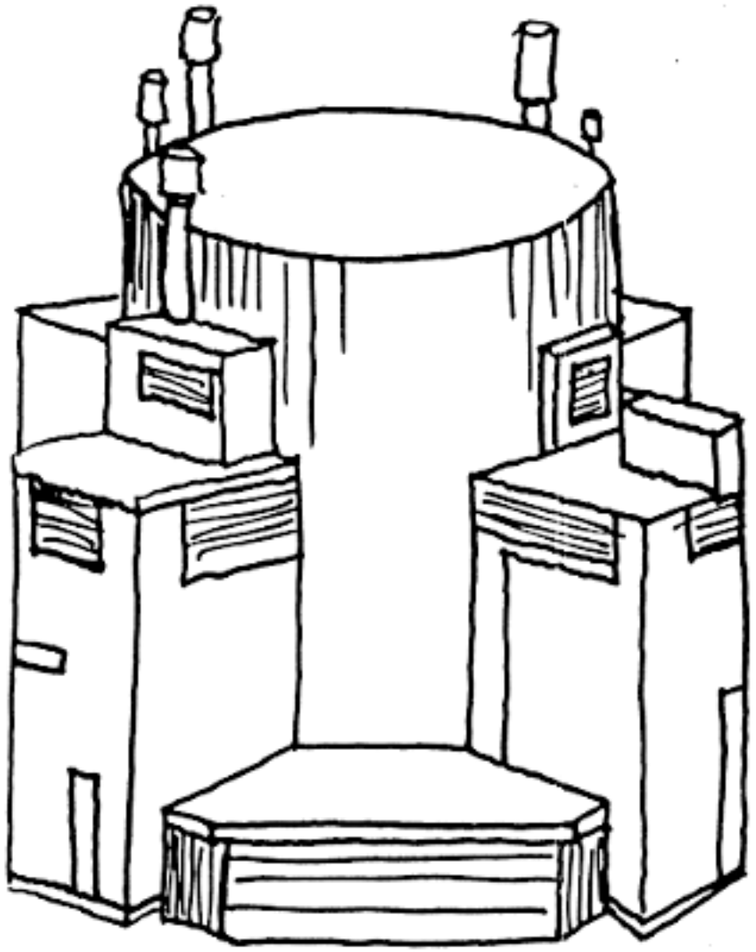
- **22/2/94 : Prime Minister announces restart *but with a new R&D mission and evolution toward Pu burning***

- **11/7/1994 : New Creation Decree**

Superphénix : Part 2

- **25/12/1994 : Shutdown (Argon leak in IHX feeder) in situ repair by expanding sleeve**
- **25/8/1995 : Repair completed. Request for restart**
- **4/10/1995 : «Castaing» Commission nominated. Report issued 20/6/1996 : *see below***
- **22/12/1995 : Restart 30%. 2/96 : 60%. 10/96 : 90%**
- **5/1996 : planned outage (CR Shuffling)**
- **25/12/1996 : planned shutdown (6 monhs)**
- **28/2/1997 : «Conseil d'Etat» voids Creation Decree**

Superphénix : 1996 in brief



95% Availability (vs planned)

250 days connected

3.5 billion kWh

Positive Castaing Report

Experimental Capra subassemblies delivered

Argon leak repair stable

probably the best year since start-up...

DRN

Knowledge Acquisition (PAC)

Ordered by Prime Minister 22/2/1994
Established by NERSA, EDF & CEA 29/4/1994
Evaluated by MM. Dautray, Detraz 31/5/1994
Included (Art.3) in Creation Decree 11/7/1994

3 complementary goals :

- **Obtain industrial experience in FR operation**
- **Demonstrate FR flexibility and qualify solutions for Pu consumption (CAPRA)**
- **R&D on LL radwastes destruction**

CAPRA R&D Programme

WHY

Breeding no longer urgent *and fully demonstrated*

Reprocessing and MOX recycle with incentive to limit Pu stockpile

Specific merits of Fast Reactors : Plutoniums, MA

***At least* 10 years to fully assess burning capability (which concerns only core and fuel, ~ 10% plant)**

HOW

- **93-94 : Feasibility Oxide core 45% Pu**
- **95-98 : Validation oxide core design**
  Feasibility cores without uranium
  Fuel fabrication and performances

«Castaing» Recommandations

Carry out basic research on materials

Set up Scientific Advisory Board

PAC.1 Increase reliability and safety, rather than focus prematurely on performãnces and economics

PAC.2 Demonstration of global Pu burning ability not urgent

PAC.3 Accelerate R&D on Americium (1991 Law)

L

«Casting» Consequences

Experts Group on Materials Research in/for Spx

Increase in «ISIR» programs of CEA

ARCOPAC project for PAC results conservation

Cooperative R&D on alternative coolants

Development of special subassemblies to increase technological irradiations in Spx core

New experimental irradiations, incl. Am in core2

International Cooperation

European «EFR» Cooperation :

Utilities : EFRUG + Engineering EFR Associates + R&D Serena/Fastec

R & D

- Japan : **PNC-CEA and Europe-PNC/JAERI/ CRIEPI/JAPC**
- Russian Federation : **CEA-Minatom (1994)**
- China : **CEA-CNNC (1995)**
- Others : **PSI, GE, various CAPRA partners**

(plus information exchanges between reactor operators : Phénix with Monju, Aktao, BN600 and Superphénix with monju)

EFR EUROPEAN FAST REACTOR ASSOCIATES

WORK PROGRAMME OUTLINE

1995 | 1996 | 1997 | 1998 | 1999 | 2000

Feedback from FR operating experience

Reference EFR: Nuclear Island design progress

- Optimised for economic power generation
- Consolidate EFR CD design features
- Introduce CAPRA core as Reference burner variant

Innovative Concepts — Generic studies

- Innovative designs / alternative basic FR options
- Core and fuel performance, breeding/burning flexibility
- Safety issues: WCA, containment, Na fires
- ISI & R improvement
- Structural materials, design rules, computational tools

International collaboration: Japan, Russia, ...

Propose to EFRUG improved Nuclear Island designs to suit their strategic requirements

Implement common work in identified areas

Japan FBR Program (private comments)

Poor in fossil energy ressources (like France), Japan has made a long-term commitment to nuclear power

For countries depending upon nuclear power, FBR program constitutes a kind of insurance premium against future uranium scarcity (*sustainability*)

The Japan FBR program appears to be continuous, progressive, and with well defined milestones : JOYO, MONJU, DFBR within a realistic time frame

Japan is well connected with foreign FBR R&D

From a *strictly technical* point of view, the MONJU incident was minor (>100 Na leaks...)