

Long Term Strategy and Nuclear Fuel Evolution

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The nuclear fuel fabrication industry is characterised by a continuous upgrading of the end product, the fuel assembly, driven by the needs of utilities and by feedback from operating experience. This paper presents the perspective of Framatome on the outlook for the fuel fabrication industry.

The Benefits of Higher Burnups

Increasing burnup, which allows the utility to get the same kWh output with a reduced tonnage of higher enriched fissile material, provides a saving not only in the cost of fuel fabrication but also in the cost of disposal of the irradiated fuel. This latter cost is two to four times higher than that of fuel fabrication. Reducing the quantity of irradiated fuel also has a positive impact on the environmentally acceptable solution adopted for its disposal.

This is true not only for fresh uranium fuel, but also for mixed oxide (MOX) fuel. For MOX fuel, the goal is to achieve the same higher burnups as with uranium fuel. Higher burnups make MOX fuel more competitive in comparison with fresh uranium fuel, because the latter requires more uranium feed and enrichment to achieve higher burnups.

Meanwhile, the safety authorities are increasing their requirements to license higher burnup fuels, asking for more representative material tests under accidental conditions, more feedback from experience with lead test assemblies, etc, before granting a licence. Meeting these more and more stringent constraints requires heavy equipment

programmes which must encompass a large amount of feedback from engineering and operating experience, the use of heavy testing equipment, and careful step by step licensing.

In France, for example, Framatome is in charge of the engineering, the Commissariat à l'Energie Atomique (CEA) of the testing equipment, and Electricité de France (EDF) of the licensing. Thus was born the French fuel design AFA 3G, now ordered by EDF for all its reactors. With the new M5 alloy cladding, it has also been ordered for reactors in Sweden, Belgium and South Africa, and is in the process of being licensed for a 20% increase in burnup, to 60 000 MWd/t.

The next product under development, called "Alliance", has a goal of reaching 70 000 MWd/t assembly burnup, which will further reduce quantities of fuel required by 15%. Together, these two steps will reduce the quantity of fuel required by more than one-third, and further steps will certainly follow.

Competition and R&D Financing

Achieving such higher burnups requires a substantial financial investment in research and development (R&D). Taking into account the costs of heavy testing equipment, in France, for example, this is in the range of FFr 500 million (US\$83 million) per year.

Competition between fuel fabricators is necessary to promote such increases in burnup, which are not directly in their own interests as they reduce the requirements for their product. But strong competition can make it difficult to finance the

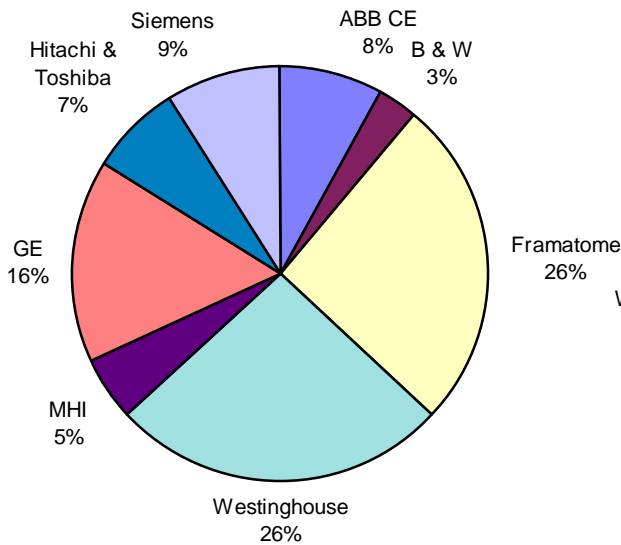


Figure 1. Western installed LWR capacity, by reactor vendor (Source: Framatome).

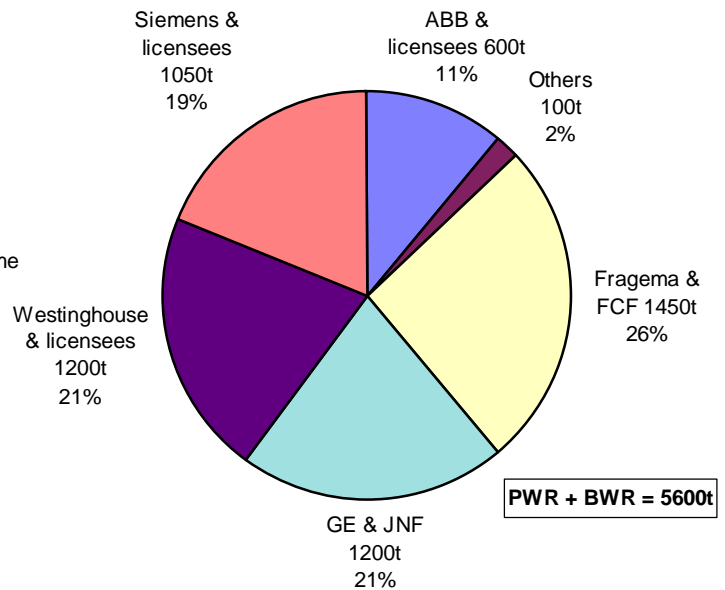


Figure 2. Market shares for Western LWR fuel fabrication, by fuel supplier (Source: Framatome).

necessary R&D. Increases in burnup would eventually yield much higher cost savings for utilities than an immediate drop in fabrication prices, which would impair the financing of the necessary R&D.

Part of the supply of fuel fabrication has been sheltered from competition. Up until now this has been the case in countries like Spain and Korea, where a domestic supplier has had a dominant position in a small market; and also for fuel for some less common reactor types, due to the relatively high technical barriers and the small market size. This has applied to Magnox and AGR reactors, to some reactors of Babcock & Wilcox and Combustion Engineering designs, and a limited number of other small reactors.

However, fuel fabrication for the bulk of installed LWR nuclear capacity is now open to full competition (see Figure 1). This includes Westinghouse, Framatome, and Mitsubishi Heavy Industries (MHI) reactor types (comprising 57% of all LWR capacity), General Electric (GE) types (including Hitachi and Toshiba) (23%), and Siemens reactors (9%). For BWR fuel, competition is among GE, Siemens and ABB, and for PWR fuel type among Framatome, Siemens, ABB, and Westinghouse and its licensees.

The market share of Western LWR fuel fabricators in 1998 is (Figure 2):

- Framatome/Cogema Fuels: 26%,
- General Electric/JNF: 21%,
- Westinghouse/MHI: 21%,
- Siemens: 19%,

- ABB/Combustion Engineering: 11%,
- Others: 2%.

The maximum turnover of the nuclear fuel business of the first four groups, probably in the range of FFr 3 billion (US\$500 million) each, shows that an R&D effort of FFr 500 million per year represents about 17% of turnover, which is quite a high figure and requires very high margins.

Several methods have been used to try and overcome this difficulty. Some utilities contribute to fuel R&D funding directly, independently of payments for fuel they purchase. Some countries have supported part of the test equipment costs. Some basic R&D is done in the form of international programmes, such as the Electric Power Research Institute (EPRI) programme, to which all companies can contribute.

Restructuring

The need to finance R&D is a driver of the strategies of fuel producers. It has led producers to sell worldwide, and to extend their product areas. All the major producers are now manufacturing (either directly or through licensees) in each of the three main Western markets of the USA, Europe and Asia (see Table 1).

Producers also tend to share components manufacturing, to benefit from economies of scale. In zirconium, mainly in the BWR market, Westinghouse supplies GE, while Framatome supplies GE, Siemens and ABB.

There has also been a trend to consolidate manufacturing facilities, to better recoup high

Table 1. LWR fuel fabrication facilities of the major fabrication groups in North America, Europe and Asia.

Group	North America	Europe	Asia
Framatome	Lynchburg	Uranium: Romans (France) & Dessel (Belgium) MOX: Cadarache & Marcoule (France)	(Yi-bin)
General Electric	Wilmington	Juzbado (Spain)	Yokosuka
Westinghouse	Columbia	Uranium: Springfields (UK) & Juzbado (Spain) MOX: Sellafield (UK)	Tokai-mura
Siemens	Richland	Lingen (Germany)	Tokai-mura
ABB/CE	Hematite	Vasteras (Sweden)	(Taejon, Korea)

fixed costs. Siemens has closed its Hanau plant in Germany, Combustion Engineering has stopped uranium operations at Windsor in the USA, and Framatome is closing its plant at Pierrelatte, France.

Certainly, the need to enlarge the commercial base in order to finance the development of new advanced products is an incentive for joint R&D in the fabrication industry. Such projects have to meet anti-trust legal requirements. However, some would clearly promote future competition, provided they help overcome long term R&D financing difficulties.

There are two other ways to help meet R&D financing requirements. The first is to develop international research programmes, mainly in the areas of safety and environmental protection. The second is for utilities to develop R&D partnerships with their suppliers.

Conclusion

It is well known that the market prices for fuel fabrication vary over a wide range, by a factor of

about three. The extremes of this range occur in the USA and Japan. This explains the present tendency of falling prices in Japan and to some extent in Europe.

However, recent low price levels in the USA, due to fierce competition, would, if applied generally, make it impossible for Framatome, and I believe for others too, to continue adequate long-term R&D. Utilities have more to gain from higher burnups than from depressed fabrication prices.

Of course, utilities which do not believe that their nuclear plants have a long term future may favour short term savings. But most of the large utilities believe that much more competitive nuclear energy is achievable (to which higher burnups can contribute), and they consistently enter into partnerships with one or more suppliers in which well-oriented and well-managed fuel design R&D plays a major role. Such behaviour can open the way for a revival of nuclear power generation, which is necessary for the long term clean energy needs of the world.