A LOOK AT NUCLEAR RESEARCH EFFORTS FOR THE SPANISH ELECTRICITY SECTOR

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The present article contains an analysis of the nuclear-related research carried out by the Spanish electricity sector, taking into account the peculiarities of both the national electricity system and the country's installed nuclear power and of the role played by research within the framework of the Spanish economy.

THE SPANISH ELECTRICITY SECTOR

The Spanish electricity generation and transport industry dates back to 1875, the year in which the country's first electricity generating station was built. The 66 kV alternating current line laid between Madrid and Valencia in 1908 constituted an important milestone, since it was the first line of its type in Europe. The founding in 1944 of UNESA (Unidad Eléctrica, S.A.), an association of the country's leading electricity utilities, allowed generation and transmission to be integrated at national level.

The Spanish Electricity Sector is currently made up of some 900 generation and transport companies of different sizes. Of the national production, 96% is generated by the 12 companies belonging to UNESA.

The Spanish Electricity Sector is a regulated one. The role played by the Administration is of outstanding importance for two reasons: the basic operating principles are established by standards (there is no free competition) and a substantial part of the facilities is state owned (part of generation and distribution and all transmission). The basic principles referred to above are four:

Uniform rates for the entire country; unified operations management (by a majority publicly held grid company); joint planning of long-term capacity requirements (by the Administration) and consideration given to electricity as a public service.

The first three of these principles remove the possibility of setting up a situation of open competition and therefore take away from the market its role as an instigator of efficiency. The uniform rates affect price as a variable; joint planning established outside the corporate framework impacts the strategic planning of the different companies (long-term decisions), and the unified operation of the electricity system determines operational decisions.

The framework within which payment is made for electricity-related activities consists of a series of standards known as the "Marco Legal y Estable" (Legal and Stable Framework) (MLE) and, in a sense, constitutes a compensation for the three principles described above. Thus, on the one hand and following authorization, the rates are determined in such a way as to cover the costs incurred and recover investments, such that reinvestment becomes a possibility (allowed costs). On the other hand, a system of compensations between companies is set up, the aim being to distribute costs and income in an equitable manner. The compensatory system incorporates certain mechanisms intended to bring about efficient operation.

T I - *Installed capacity and electricity generated (1993)* [1]

TYPE OF PLANT	INSTALLED CAPACITY			ENERGY PRODUCED	
	MW	%	Nº of Plants	GWh	%
Hydroelectric	16,996	36.6	886	25,104	15.7
Fossil-fuelled	21,989	47.4	134	78,389	49.1
Nuclear	7,400	16.0	9	56,060	35.2
TOTAL	**46,385**	**100.0**	**1,079**	**159,553**	**100.0**

(1)Gross production. National total.

Overall, the MLE goes to make up a model which is referred to in economic literature as yardstick competition, in which competition is established with respect to a standard.

CHARACTERISTICS OF THE SPANISH NUCLEAR INDUSTRY

The Spanish nuclear industry has two characteristics that place it in a special position: 1) there is no national NSSS vendor and 2) the plants are of different origin (W, GE and KWU[2] and together have a low average age (the youngest in the OECD). Among the countries of equivalent political and economic conditions to those of Spain, Finland and Switzerland present these same characteristics, along with three others: a) a similar participation by nuclear power in overall electricity generation (around 35%), b) the presence of both public and private electricity utilities, and c) excellent load factors (approximately 85% in Spain and Switzerland and 90% in Finland).

The lack of a national NSSS vendor is not in itself an undesirable characteristic. In addition, on an international market where business opportunities are currently very limited and where economies of scale are sought through mergers, reconversions and joint-ventures, there would be no sense in contemplating the constitution of such a company, since, given its size and characteristics it would undoubtedly require some degree of support by the Administration. This would lead to undesirable pressures on the customer and reduce his capacity to negotiate, which would in turn and in principle influence initial costs[3]. This "shortcoming" of the Spanish nuclear scene has made possible and facilitated the existence of a wide range of technologies, an aspect which will be dealt with below.

The disadvantages of not having a main vendor in Spain are quite clear from the point of view of the country's industrial policy. From the business point of view, these disadvantages would be limited and would arise in terms of the fluidity in supplier-utility communications and, perhaps, of services or supply costs during plant operation.

The second characteristic - the existence of technologies of diverse origin - is partially a consequence of the first, and attention might be brought to the associated advantage provided by the high level of technical capability developed by both the owners and national auxiliary suppliers. As regards the disadvantages, mention might be made of the fact that, on the one hand, the coexistence of various designs constitutes an obstacle to the development of economies of scale by owners and suppliers alike and that, on the other, it makes coordinated action more difficult. The conjunction of all these factors has led to unequal installation costs, to competitive operation and maintenance costs, to a considerable degree of operational self-reliance, to a "surplus" of exportable high-level technological capability and to the establishment of coordinated organizational structures within the framework of UNESA.

(2)The Vandellós I graphite-gas plant, of French origin, was definitively shut down in 1989 after 17 years of operation.

(3)Consideration should be given to the fact that the cost of the contract with the main supplier is only one component of the total construction cost. Auxiliary supplies and engineering are also an essential part.

THE ROLE OF R&D

In a modern economy, R&D is a tool that allows companies to adopt a suitable market position in the medium or long term. The objective having been determined, R&D aims to provide a response to the technological demands made with a view to meeting such demands, and is given a degree of importance comparable to other areas of business management, such as production or commercial activities. This degree of importance should be even greater in activities of high technological content, such as electric generation by nuclear means.

Although it is not the subject of this article, the social role of R&D not related to economic welfare should not be underrated. This role consists basically of satisfying the need for knowledge - in short, the cultural need - of the more advanced societies.

In practice there are four characteristics of R&D that tend to maintain it in disassociation from business management:

- **The term.** Depending on the complexity or urgency of the objective sought, results are obtained in the medium or long term, not in the short term. Thus, the "tempo" of research sets it aside from production activities, which are required to provide immediate solutions and obtain immediate benefits.
- **The risk.** The risk associated with R&D investments is greater than that involved in "common" investments (e.g., the simple acquisition of new equipment). This leads to the search for administrative subsidies and business alliances, with a view to minimizing or sharing the risk.
- **The volume.** The financial requirements associated with R&D are currently growing. This has a dual effect. On the one hand, the tendency is to look for "travelling companions"; on the other, the larger companies with greater investment capacities are favoured to the detriment of the smaller ones.
- **Human resources.** The role of human resources in R&D is essential, not only in terms of cost (which is normally the bulkiest budgeting item) but also as regards quality. The effect of the experience curve on research personnel training is particularly notable. To this should be added a "cultural" factor which removes the behaviour patterns of research workers from those of the production personnel, this being an area of potential conflict.

In other words, the role of R&D in the company is the result of two opposing forces. A driving force which, encouraged by the market and, ultimately, by profit and survival, leads to technological improvement, and a demotivating force which, as a result of the four characteristics described above, tends to depreciate R&D or set it aside from the mainstream.

Although emphasis is laid here on the role of the market as a driving force for technological innovation, we should not forget the role played by the Administrations which, through standards (local, national or international) are able to bring pressure to bear in the same direction. A clear example of this is protection of the environment which, although in the future might find its way into the laws of the marketplace as one more component thereof (with the assignment of prices to natural resources), is currently the concern of the Administrations. In this context the role of the Administration is said to be that of correcting "market faults".

R&D IN SPAIN

The Spanish science and technology system has experienced considerable growth rates over the last few years, much higher than those recorded in the most highly developed nations. Nevertheless, the indicators traditionally used continue to describe the Spanish system as being of small size, as may be observed in Table II.

Let us consider by way of a reference that while the Spanish GNP represents approximately 7% of that of the European Union, the spending on R&D in Spain amounts to only 3.6% of such expenditure in the EU.

It is interesting, however, to analyze the results obtained: scientific production in Spain amounts to 5.5% of that achieved by the EU (with only 3.6% of expenditure in absolute values and a value relative to the GNP 2.3 times smaller). The same may be observed with respect to the USA and Japan. In other words, the scientific performance achieved is higher than that of the most advanced nations.

With regard to another fundamental indicator, the cover rate of the technology transfer balance, the situation is different. The American rate of coverage is 29 times greater (and most certainly higher than 1), and the Japanese 5 times greater. However, comparative analysis is of no interest, the issue of interest being the absolute value. Although in 1991 and 1992 this rate grew to values higher than 0,25 [7], the result is still the same: Spain is clearly an importer of technology.

These data support the idea that for many decades the technological progress achieved has not mainly been

RESOURCES	SPAIN	EU	USA	JAPAN	OBSERVATIONS
E(R&D)/GNP	0.85	2.00	2.77	3.07	E = Expenditure on R&D with respect to GNP
R(R&D/W.P.) %o	2.2(4)	4.2(4)	7.6(5)	8.9(4)	R = Researchers with respect to working population
RESULTS					
Scientific production	10,736	194,399	248,308	48,745	Publications (ISI, Philadelphia)
Cover rate of the technology transfer balance	0.18	(6)	5.26	0.91	Technology exports over imports

T II - *R&D Indicators (1990 data)*

the result of the national science-technology-industry system but rather of the acquisition of technology on the international markets. The figures would also seem to support the theory that this has not been the result of faults in the first link in the chain but rather in the last, that relating to the incorporation, assimilation and transfer of technology to the field of production.

According to the surveys carried out within the framework of the EU, the interest in science and technology shown by Spaniards is absolutely in line with that of their European neighbours. There is a large degree of coincidence in opinions as regards the importance and benefit for society of science and technology. The supposed barrier that tends to separate research from production is, therefore, apparently to be found in the world of business. As may be appreciated from the aforementioned surveys, this effect would appear to be heightened in Spain by greater fear of the impact of technology on the loss of jobs.

NUCLEAR R&D IN THE SPANISH ELECTRICITY SECTOR

- The regulatory framework

In Spain, the national guidelines governing energy issues, including the associated research, are contained in the National Energy Plan (PEN) approved by Parliament, which covers the different energy subsectors: electricity, coal, gas and oil, for a period of several years (the current plant covers the period 1991-2000).

By decree, financing of the R&D associated with the Electricity Sector comes from a levy of 0.3% on electricity sales, and is administered by the Management Board of OCIDE (Office for R&D Coordination in the Electricity Sector), which is made up of representatives from the Administration and the Electricity Sector and presided over by the Ministry of Industry and Energy.

In view of the peculiarities of the Spanish Electricity Sector described above, with regard to both operation and its compensation scheme, this rather atypical way of dealing with R&D must be stressed. The market being eliminated as a driving force for innovation,a centralized mechanism is set up in an attempt to replace it.

- Courses of action

Among the different activities involved in the electricity business, generation is the one with the highest technological content and which makes the largest contribution to the cost of the kWh. Although this contribution has gradually decreased over the last few years, it represents approximately 70% of the cost, with an annual volume of 10 billion dollars, including the costs of fixed assets, operation and maintenance and fuels. Between 35% and 40% of the generating costs correspond to nuclear plants, amounting to a turnover of some 3.9 billion dollars annually (allowed costs). However, and in view of the tariff's system (which guarantees the recovery of investment costs), plant operation and maintenance (O&M) is the area in which the operators have the greatest margin for action and in which incentives may exist. This reduces the figure to some 600 million dollars annually.

The "natural" objectives of research are, therefore, those relating to O&M, leading to improved efficiency, the reduction of unavailabilities, the life extension and the improvement of safety. These imply in turn others, such as training improvement, compliance with regulatory requirements, modernization of facilities, surveillance of materials and components or the duration and reliability of inspections. In summary, the aim is to reduce O&M costs while maintaining high levels of production and safety, and to maximize the profitability of the facility.

Apart from these "natural" objectives, and as regards the Electricity Sector, the PEN establishes a series of additional guidelines in relation to research:

- Promote R&D by the companies.
- Concentrate efforts on technologies such that dependence on overseas suppliers may be reduced.
- Participate in international initiatives.
- Promote horizontal integration (among companies).
- Increase the capacity of the Spanish nuclear industry to obtain designs for the advanced plants which will constitute the basis for future nuclear programs (sic).

In this way, the objectives described above are economic in their motives and originate within the companies. The rest originate in initiatives undertaken by the Administration: the first and second relate to structural shortcomings of the country itself (as was seen in point "the role of R&D"); the third is the result of limitations on the available resources, due to national dimensions, and the last two are a consequence of the operational peculiarities of the Spanish Electricity Sector: one in relation to the policy of compensations between companies and the other to the responsibility of the Administration regarding the planning of future equipment.

The basic source of financing is common to all the objectives described (0.3% of the income from the electricity sales (8)), and assignment of these resources to the Research Program is, as has been pointed out, ultimately controlled by the Administration.

- The program.

The "Programa Marco de I+D Nuclear del Sector Eléctrico" (Electricity Sector's Nuclear R&D Framework Program) is the governing document for all the activities of the Sector in this field, and has a four-year span. The program currently in force covers the period 1991-1994. At present the program is made up of 20 on-going projects in 6 areas: Materials, Operation, Components and Systems, Safety, the Fuel Cycle and New Technologies of Generation. The total budget amounts to some 80 million dollars, of which 60% is destined to advanced reactors.

There are in addition some fifteen proposals for new projects corresponding to a total of almost 40 million dollars and giving special attention to issues relating to O&M. From the beginning, the resources allocated to nuclear-related

(4)1989 data.
(5)1987 data.
(6)1988 data: Italy 0.54; France 0.08; Germany 0.84.
(7)It should be pointed out that as from 1992 the method used to obtain this indicator has changed. The aim is currently to set up an information system similar to that used by our neighbor countries.
(8)This amount covers 50% of the financing needs.

Continued on page 49