Spreading nuclear energy in Southern Europe: the large projects in Catalonia

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Abstract

The expected growth of electricity demand, jointly with the insufficient capacity of the traditional production technologies (based on hydraulic and thermal power plants), led to the electrical producer companies in Catalonia planning the construction of eight nuclear power units of around 1000 MW each. The consequences of the international oil crisis on energy demand was behind the cutting back of the project a few years after. By the mid 1970s, only four units had received provisional authorization. Contrary to what had happened with first-generation nuclear reactors, the promoter companies were the main agents of the decisions related to site election, technology, and providers, which were only regulated in terms of the compulsory administrative authorization, minimum required national participation, and nuclear safety principles.

Keywords: nuclear energy, second- and third-power plants generation, Ascó NPP, Vandellós II NPP, electric production.

JEL Codes: L94, N74, O13, Q41

1. Introduction

What explains the expansion of nuclear energy projects in Southern Europe? This article focuses on Catalonia, a dynamic economic region with high electricity consumption. By 1950, electricity production in mainland Spain was segmented into six zones – or *Zonas* – that were scarcely interconnected: Andaluza, Aragonesa, Catalana, Centro-Levante, Centro-Norte, and Noroeste.[1]

1 The *Zonas* corresponded to the area covered by the production, transport and distribution centers of one or more electricity companies. These zones were slightly different than the administrative regions. During the 1960s, Catalonia was delimited by the area of action of

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The production within each of them was under the control of companies, more or less small, dedicated to the production and distribution of electricity and self-sufficient industrial producers. Hydraulics was the main power generation technology in the *Zona Catalana* (which comprised the four Catalan provinces and adjacent small areas). Given the practical coincidence, both geographical and of the market, between the *Zona Catalana* and the region of Catalonia, these terms will be used synonymously from here on.

Hydropower production provided almost 100 percent of the power supplied by electrical companies in Catalonia. Despite the enormous investment effort made in increasingly large reservoirs, the rising demand exceeded the growth possibilities of this energy source and the increasing need for capital was shutting out smaller competitors. More specifically, during the 1950s, electricity production in the Catalana area was concentrated between four companies: Fuerzas Eléctricas de Cataluña (FECSA), Empresa Nacional Hidroeléctrica del Ribagorzana (ENHER), Hidroeléctrica de Cataluña (HECSA), and Fuerzas Hidroeléctricas del Segre (FHS).[2]

In view of the growth in demand and the saturation of hydraulic capacity, these companies accelerated the construction of thermal power plants, showing a preference for those that burned fuel oil, since the coal existing in the zone was lignite, a low caloric fuel that resulted in high costs of electricity production.

Meanwhile, the geostrategic competition between the United States and the Soviet Union led to US President Eisenhower offering to share knowledge on nuclear energy for peaceful use in 1953. This offer was viewed with interest by the Catalan companies and the academic community and soon became an option for the development of their electricity production systems. This interest led to the design and construction in the municipality of Vandellòs i l'Hospitalet de l'Infant of a nuclear power plant of the so-called first generation.

First-generation plants have traditionally been considered the three plants whose construction began in Spain before 1970 (José Cabrera – Zorita, Santa María de Garoña, and Vandellós I), all of them built through "turnkey"

four large companies (and some other smaller ones); geographically, it coincided with the territory of Catalonia (the northeast of Spain), plus a small portion of the Aragon region whose electricity grid was managed by ENHER.

2 In 1946, Catalana de Gas y Electricidad segregated its electrical assets to found with them (and with the support of the Urquijo and Hispano Americano banks) Hidroeléctrica de Cataluña (HECSA), which later, in 1965, would absorb another of the investees of Catalana de Gas, the Compañía de Fluido Eléctrico. Also in 1946, INI founded Empresa Nacional Hidroeléctrica del Ribagorzana S.A. (ENHER), with the aim of exploiting the hydraulic capacity of the Noguera Ribagorzana basin. A year later, Fuerzas Hidroeléctricas del Segre (FHS), of the Gomis group, was born through the absorption of Compañía Anónima Manresana de Electricidad, Fuerza e Iluminación S.A. and Explotaciones Hidroeléctricas S.A. The scheme was completed with the foundation in 1951 of Fuerzas Eléctricas de Cataluña S.A. (FECSA).

projects[3] and with powers of less than 500 MW. The second-generation plants were Almaraz, Lemóniz (unfinished), Ascó and Cofrentes, plants of about 900 MW built through contracts with "packages" that received prior authorization until 1972. The rest of the plants built, proposed or devised thereafter are what are known as third-generation plants.

Although the first-generation plants were born from the impulse of the electricity companies, their development was given the unconditional support of the Nuclear Energy Board (JEN) – which saw in the projects a means of guaranteeing energy autonomy in Spain through the use of uranium reserves (Sánchez and López 2021, p. 110) – as much as the Ministry of Industry, interested in promoting the development of domestic manufacturing.[4]

These first-generation projects benefited from a market that was beginning to expand, fed by American companies but also the English and French, who offered, at that time, reactor technology based on burning natural uranium; an option preferred by the JEN. Vendor companies involved in this market had the political and financial support of their respective governments (if not their direct intervention).

However, this first generation was limited by immature technology. The limitations in the quality of the materials of the primary system equipment (reactor vessels, mainly) conditioned the power of the light water reactors and the existing industrial processes did not allow for the manufacture of larger equipment (turbines, generators and power transformers), limiting the final power of the reactors to levels below 500 MWe.

It was not until the late 1960s when second-generation power plants were conceived, that those last difficulties had been overcome and reactors could double that power. National energy planning had been carried out by the electricity companies through UNESA.[5] At the same time, new players began to appear in the nuclear market – Kraftwerk Union[6] and the General Swedish Electrical Limited Company (ASEA),[7] among others – although they were then still more ac-

3 In a "turnkey" project, the main contractor assumes responsibility for the design and construction of the plant, guaranteeing price and deadlines. In a "package" contract, the developer contracts the main equipment from the principal provider, reserving decisions on the rest of the supplies and detailed engineering. A further clarification of the ways used to contract a nuclear project can be found in García Rodríguez (2021, pp. 24-26). De la Torre and Rubio Varas (2018, p. 110) offer an account of the application of the turnkey contract for Zorita and Santa María de Garoña.

4 After previous exploratory contacts in France between López Bravo, Spanish Minister of Industry, and Otero Navascués, president of the JEN, in 1964 the latter was appointed in charge of the Vandellós I project. Caro (1995, p. 186).

5 The National Electricity Plan of 1969, prepared by UNESA and approved by the Ministry of Industry and Energy. See also De la Torre and Rubio Varas (2018, p. 111).

6 Founded in 1969 by Siemens and AEG, to enhance their capabilities in the nuclear market.

7 In 1966 the construction of Oskarshamn started and in 1969 that of Oskarshamn II and Ringhals I (all of them BWR).

tive in their respective domestic markets than in international markets, dominated by the American companies (mainly Westinghouse and General Electric). Light pressurized or boiling water plants (PWR and BWR) were imposed on the market.[8] In France, Framatome started the project of construction and export of light pressurized water plants (PWR) from 1969 with Fessenheim.[9]

Finally, the third-generation plants, having similar technology to that of their predecessors, experienced during their design the intensification of increasingly demanding safety measures, which raised their costs and the expected construction periods. The industrial crisis of the mid-1970s emerged during the development of the projects, both in Spain and in the rest of the Western countries; the exaggeration of previous electricity consumption plans provoked the cancellation of numerous projects.

The present work is a chronological description of the facts and the most significant circumstances that surrounded and conditioned the planning and design of the large second- and third-generation nuclear power plants in Catalonia, up until the prior authorization was issued;[10] a period on which in-depth historical analysis is lacking.

Although any specific outcome is the product of many causes, the main reason for the planning of large power plants in Catalonia during the early 1970s was the forecasting of electricity demand increases; and the reason for its subsequent paralysis was the fall in the growth of electrical consumption after the industrial crisis that followed the oil crisis of 1973 (Pascual Martínez 1977, p. 9).

The sequence of events will allow us to understand the technical and economic logic that led to the selection of pressurized water reactors (PWR) manufactured by Westinghouse for these projects. In the documentation consulted, it is evident the level of independence with which the companies involved in the projects discussed here acted.[11] However, it is worth pointing out that they were subjected to the opinion of SERCOBE (the Commercial Technical Service of Manufacturers of Capital Goods) with regard to the freedom to acquire equipment abroad, in order to ensure compliance with the obligation to achieve the minimum required national participation in the projects.[12]

8 These plants, which consumed enriched uranium (about 5%), offered technical advantages over their competitors; especially once it was possible to build units of more than 500 MWe, capable of withstanding the pressures to which materials are subjected in light water reactors. Since enrichment was then a monopoly of the U.S. (in the West), American companies arrived earlier and started with an advantage over the competition.

9 The erection of this plant started on 1 September 1971 and its commercial operation on 1 January 1978.

10 The phase 1 exposed in De la Torre and Rubio Varas (2018, p. 117).

11 As mentioned in De la Torre and Rubio Varas (2018, p. 111)

12 Minutes of the 26 April 1974 SERCOBE meeting over the petition of exception certificate for C.N. Ascó II NPP. A. ANAV, Box M34-D3-4.

The period covered by the present work ends before the social movements opposing the erection of nuclear power plants had enough strength (from 1976) – by then, the L'Ametlla de Mar and Escatrón nuclear power plant projects were already cancelled – and before the effects of price increases and the rise of interest rates put at risk the financial structure of the promotor companies.

The goal of this work is to fill the gaps of a period that has been scarcely studied in the past. To date it has been common to extrapolate conclusions obtained from first-generation plants (particularly the active support from JEN and the pressure to select the technology and main provider),[13] or to anticipate circumstances that were not present until a later period (lack of public acceptance and financial crises).

On the reasons for the offer made by Eisenhower with "Atoms for Peace", there is extensive international literature.[14] Regarding the reception of this technology in Spain it is worth mentioning, among others, the works of Albert Presas (2005), Pablo Soler (2017), Sánchez Ron (Sánchez Ron 2017; Romero de Pablos and Sánchez Ron 2001), Joseba de la Torre and Maria del Mar Rubio (2018), and the contribution of Joseba de la Torre, Maria del Mar Rubio and Maria Gloria Sanz (2018) on the role of scientists and technicians in the implementation of the nuclear program. Additionally, several articles have been published in the journal *Energía Nuclear*, edited by JEN since 1957. Specifically for the Catalan case, it would be possible to include in this group the research on the Argos reactor carried out by Barca Salom, cited above.

Several investigations, such as the works of Esther Sánchez and Ana Romero, have focused their interest on the construction of first-generation nuclear power plants, highlighting both the circumstances and the institutional and diplomatic efforts and pressures that made them possible (Sánchez Sánchez and Prat Sabartés 2017; Sánchez Sánchez 2011; Marty and Sánchez 2000; Romero de Pablos 2019; 2012). The journals *Energía Nuclear* and *Nuclear España*, issued by the Sociedad Nuclear Española (SNE), have dedicated specific papers to first-generation plant projects.

The social acceptance of nuclear energy has earned special attention from researchers since 1977, when the International Atomic Energy Agency (IAEA) organized a conference on the effects of nuclear production on public opinion (Abrecht 1977). From that milestone, several works were published on the acceptance of nuclear production in countries with ongoing projects and, spe-

13 See Caro (1995, pp. 185-191), Marty and Sánchez (2000), and Romero de Pablos (2019, pp. 99-113), among others, where JEN's intervention to introduce into Spain the natural uranium technology for commercial power plants is described. Regarding Zorita and Santa María de Garoña, see De la Torre and Rubio Varas (2015, pp. 107-110).

14 Among others, Colgan and Miller (2019), Drogan (2016), and Krige (2006).

cifically, also in Spain.[15] After these first works, the number of contributions on the subject multiplied considerably in the following years. In relation to the subject discussed here, it is worth mentioning the work of Xavier García on the implications of the construction of the Ascó plant (and other industrial facilities) in the region of Ribera de Ebro (Garcia 1990), as well as the work of Sánchez Vázquez, which offers a broad perspective on the activities of the Nuclear Forum in this matter (Sánchez Vázquez 2010).

The fuel cycle has been frequently discussed in the two specialized publications already mentioned (*Energía Nuclear* and *Nuclear España*), as well as in the subsequent *Alfa*, edited by the Nuclear Safety Council (CSN). In collaboration with the SNE, professors Esther Sánchez and Santiago López have compiled in a recent work the history of the uranium cycle in Spain; this work contains an extensive bibliography on the subject (Sánchez and López 2020).

The financial aspects of nuclear projects and the influence of the American Eximbank have been analyzed, among others, by researchers De la Torre and Rubio Varas (De la Torre and Rubio Varas 2016; Rubio Varas and De la Torre 2017; 2019). Some of these works are framed within the European project HoNESt (History of Nuclear Energy and Society).

Finally, for its wide thematic and temporal coverage of the history of the nuclear sector – from its beginnings until the early 1990s – it is worth mentioning the work coordinated by Rafael Caro (Caro 1995).

Except for this last work, which offers specific, albeit brief, references,[16] it is not easy to locate publications focused on the first steps of second- and third-generation projects. To overcome this shortcoming, the present work makes use of the Endesa Foundation's funds, which contain documentation of the companies that managed the projects in Catalonia. As well as the INI archives guarded by SEPI, where information related to the institutional relations of ENHER and ENDESA is stored. And, mainly, the documentation maintained by the Ascó-Vandellós II Nuclear Association (ANAV), which includes internal reports and correspondence from the respective organizations and their managers, as well as contracts and official opinions (and technical documentation of the projects), offering detailed information on the conception of the Ascó and Vandellós II projects. The analysis of this source by researchers (as well as of funds from other power plants) had been until now very limited.[17]

15 Abrecht et al. (1977), among others; and for Spain Alvarez Miranda (1977), López Rodríguez and Corretjer Palomo (1977), were among the firsts.

16 The story about the gestation of Ascó is somewhat more extensive than that corresponding to the third-generation plants and was surely nourished (although not cited) from the same sources that have been used in the present work.

17 With the exception of the work dedicated to the first-generation power plants. See Romero de Pablos (2019).

This work is organized in three sections followed by conclusions. In the first, a brief description is made of the boundary conditions that accompanied the decisions regarding the development of the nuclear project in those years. The second section describes the debates and actions carried out up until obtaining the construction permit for the Ascó plant, the only second-generation plant in Catalonia. Finally, the last section is dedicated to third-generation projects, especially Vandellós II, the only one of them that was completed. The paper ends with a brief presentation of conclusions.

2. Background and motivation

From the mid-twentieth century, Spain experienced an important industrial transformation. In the decade from 1950 to 1960, the index of industrial production doubled (Prados de la Escosura 2003, table A.11.6). In the 15 years from the implementation of the Stabilization Plan of 1959 until 1974, the index was multiplied by a factor of four. The increase in industrial production led to a parallel increase in the demand for energy and, in particular, for electricity.

Additionally, the social transformation that provoked the displacement from rural to urban areas of millions of people, together with income increases during the period (GDP at constant market prices multiplied by 4.7 between 1950 and 1974) (Carreras and Tafunell 2005, table 17.6), caused an increase in electricity demand for domestic uses.

The growing demand for energy, both industrial and domestic, caused electricity production in Spain to go from 18,614 GWh in 1960 to 80,855 GWh in 1974 (EEE 1960, 1974). To achieve these levels of production, the electricity companies first appealed to hydroelectric production, which, if in 1960 was able to cover 84 percent of demand, in 1974 it only covered 39 percent. Once saturated, thermal production was used as a complement, requiring increasing amounts of fossil fuels. This led not only to a multiplication of coal imports by a factor of five during the period, but also to an increase in the extraction of domestic lignite (with low efficiency and, therefore, significantly higher electricity production costs, Figure 1). Additionally, it also led to the growing of imports of petroleum derivatives.

Apart from the above factors, Spanish income per person, which in 1960 was half that of the main countries of Europe, still in 1975 barely managed to reach 69.3 percent of the German, 67.2 percent of the French, or 89.8 percent of the Italian averages (Carreras and Tafunell 2005, table 17.17). Therefore, there was room for further growth. In the late 1960s there was no evidence suggesting that trends would change. This explains why companies contemplated scenarios of continuous growth in electricity demand at levels above

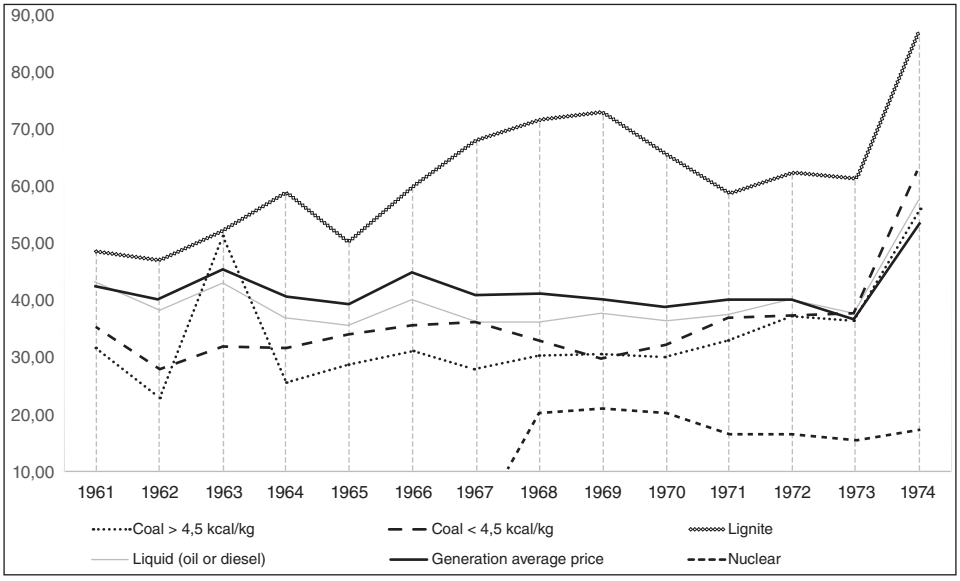
10 percent per year. On top of the expectations of sustained growth in demand, the lack of local energy resources was also problematic.

For the Administration, considering the high volumes of investment required, nuclear energy offered possibilities for technological acquisition and growth of the manufacturing industry of capital goods much faster than other industrial projects in progress (conventional thermal power plants or refineries, for example). For companies, nuclear energy meant significantly lower electricity production costs than classical thermal production costs.

The situation in Catalonia was no exception to the circumstances that conditioned electricity planning in the rest of Spain. The province of Barcelona accounted for a significant fraction (about 25%) of the value of Spain's gross industrial production and the metropolitan area of Barcelona saw its population increase from 1.2 million people after the War, to 2.2 million in 1960.

The high levels of expected demand and the lack of energy resources led Catalan electricity companies to consider the construction of nuclear power plants, with as much power as the technology of that time allowed. The progressive entry into service of first-generation power plants confirmed that the price of nuclear energy production was favorable compared to other sources of thermal production (Fig. 1). In addition, the high levels of investment required facilitated collaboration between companies for its construction.

FIGURE 1 ▪ *Evolution of the price of thermo-electric generation (cPts/kWh) according to the generation source*



Source: Author's own work. Built from data collected from the Electric Energy Statistics (MITECO).

In Catalonia there have been a total of five nuclear reactors in operation. The first was installed at the School of Industrial Engineering of Barcelona in the early 1960s and was a small reactor (10 kW) exclusively for experimental use (without commercial application) that served for the training of a large number of the technicians who participated in subsequent projects.[18]

After this, and before 1976, prior authorization was granted for the nuclear power plants of Vandellós I,[19] Ascó 1 and 2, and Vandellós II and III. The first four began commercial operation between 1972 (Vandellós I) and 1988 (Vandellós II); Vandellós III was never built. The projects for two nuclear units in L'Ametlla de Mar (Tarragona) and another two in Escatrón (Zaragoza) were not authorized.

3. Ascó NPP, a second-generation project

With the approval in June 1967 of the contract for the construction of Vandellós I, FECSA guaranteed a production of around 100 MWh in hours of maximum demand for the following decade.[20] This amount barely represented 7 percent of what it was already capable of producing in hydroelectric or thermal power plants that were either in operation or would be before 1972. Meanwhile, demand was growing at rates of more than 10 percent per year.

Facing this situation, in 1969 FECSA began the study of a project for the installation of nuclear power plants that would guarantee the company sufficient capacity to supply its market. In Spain, projects for the construction of nuclear groups in Almaraz (Cáceres) and Lemóniz (Vizcaya) were already being studied at that time.

The first studies for the construction of a new plant focused on the analysis of possible sites. On 1 March 1969, the general director of FECSA, Felipe Lafita, received a report proposing different locations in Catalonia or bordering areas. These had to be geologically stable and to have a cooling water flow of at least 30 m^3/s.[21] It was established as a safety criterion that the area had to have a low population density, for which areas were sought in

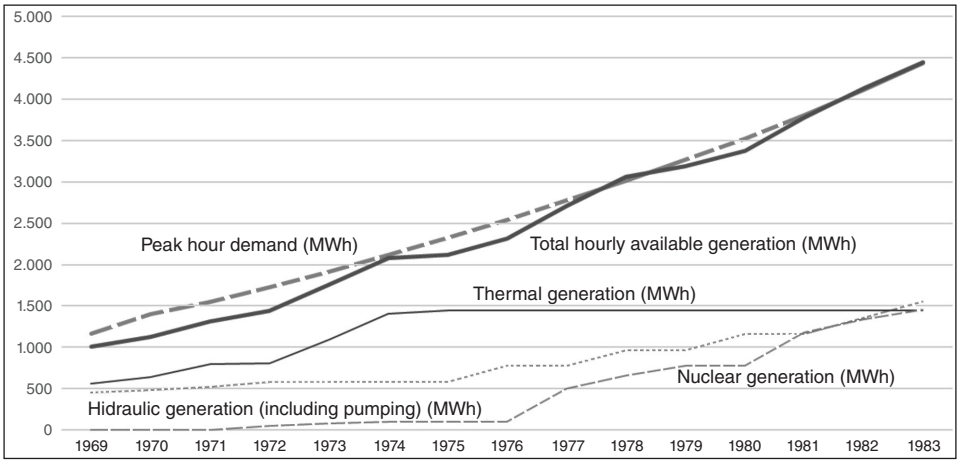
18 Barca Salom (2000) provides a detailed history of the conception of this project.

19 A 480 MWe French technology graphite-gas power plant using natural uranium as fuel.

20 Corresponding to 23 percent – FECSA's ownership share – of 480 MW, less its own consumption.

21 The cooling system of the condenser works in an open cycle, so that the cooling water is, after it has been used, returned to the river. However, the need to keep the returning water at a temperature no higher than 3ºC above that at which it is taken requires a minimum river flow and, in certain periods, the use of cooling towers. On water consumption in the Ebro see Sesma Martín (2019). This paper offers an estimate of consumption (water lost by evaporation) of 1.04 m^3/MWh (table 2, p. 6); this estimation supposes, when operating the two groups

FIGURE 2 ▪ *FECSA foreseeable power balance at the hour of maximum annual load*



Source: Author's own work. Built from the report "C.N. de Ascó. Declaración sobre las necesidades que se trata de satisfacer y justificación de la instalación" (1970). (A. ANAV, Box M33-A3-221).

which there were no population centers of more than 25,000 inhabitants within less than 30 kilometers.[22]

Five sites were preselected in Catalonia: Vandellós, Ribarroja, Ascó, Boquera (Ebro delta), and Pals; and in Castellón: Irta, although Hidroeléctrica Española had rights over the latter site and it was subject to legal proceedings brought by groups with tourist interests in its vicinity. Finally, the site of Ascó, in the area of the Andiscs, with a population density of 33 inhabitants/km^2 (equidistant at about 45 kilometers from Reus, Lleida and Tortosa, the main nearby cities) and having an average flow from the Ebro of 500 m^3/s – which guaranteed direct cooling – was chosen. In December 1969, land purchase options were formalized, with a total area of about 70 hectares.[23]

At the same time, a study on feasibility and the needs of the plant was carried out. This analyzed FECSA's ability to serve its market in peak demand periods (see Fig. 2). It contemplated an increase in peak periods of 11 percent per year for the first four years, starting from the maximum annual demand in 1969 (1,169 MWh), and then decreasing to 8 percent in 1983, the horizon year of the study. The saturation of hydraulic capacity was considered (although the incorporation of four pumping groups of 200 MW was foreseen) and the entry into operation of the thermal power plants of Serchs, Escucha

at full power, a maximum consumption of 0.5 m^3/s (although the hypothesis of continuous operation of the cooling towers is not correct, since their need depends on the river flow).

22 "Selección de posibles emplazamientos para una central nuclear de 600 MWe." A. ANAV, Box M33-A3-222 (vol. 934).

23 The final number of hectares acquired was just over 83.

(60 percent owned by FECSA) and San Adrián. The report concluded that demand could only be met by incorporating two 800 MW nuclear units into the system in 1977 and 1981 (Fig. 2).[24]

After the initial decision on the location and power (and number) of the groups to be erected, the reactor technology and contracting strategy were still to be decided. In November 1969, FECSA's management issued instructions to the project management to initiate a bidding process with Germany's Kraftwerk Union, and General Electric and Westinghouse, all of which had previously expressed their willingness to bid.[25]

The procurement system had not yet been decided, so they were asked to bid for a "turnkey" or "component" contract. Kraftwerk Union was willing to provide both systems, but American companies were reluctant to accept a turnkey contract. Westinghouse even warned of price increases of up to 8 percent for this type of contract.[26]

This position of General Electric and Westinghouse was due to their experience of previous years. General Electric's reactor commercialization strategy, later imitated by Westinghouse, based on turnkey contracts for nuclear plants in the U.S. first, and then in the rest of the world, had allowed a rapid growth in the number of awards for new plants during the 1960s. However, the increasing safety requirements for new plants put in question the financial viability of the strategy for suppliers (Walter and Wellok 2010, p. 25-27).

The decision on the type of contract was soon resolved. The advance in the projects of Almaraz and Lemóniz (jointly tendered in October 1969) allowed both to capture experiences, and to contemplate the lowering of the price by accumulation of orders to the same supplier. Iberduero representatives recommended abandoning the idea of the turnkey contract due to the possibility that the bidders (as Westinghouse had anticipated) would make more expensive offers to prevent against possible future risks. In addition, under this modality, the successful bidder could reduce the quality standards of the equipment and promote the participation of its preferred suppliers, making it difficult to achieve the minimum required national participation. For this reason, it was decided to approach the procurement through the modality of "contract by components".[27]

24 Algueró, Juan, "Declaración sobre las necesidades que se trata de satisfacer y necesidad de la instalación", April 27th, 1970. A. ANAV, Box M33-A3-221.

25 "Petición de ofertas para una central nuclear". A. ANAV, Box M33-A3-222 (vol. 935).

26 Ibidem, p. 3.

27 In March 1970, during the definition phase of the project, Juan Algueró held interviews with representatives of Iberduero (Múgica Insunza and Barandiarán), the JEN (Pascual) and Industry (Ortega Costa). "Nota de Juan Algueró a Lafita", March 4th, 1970. A. ANAV, Box M33-A3-221.

In relation to the bidding strategy, Iberduero had analyzed different alternatives comparing the cost per kWh with that produced in a fuel oil plant and for different sizes of units (Table 1). The analysis concluded that the partnership was advantageous in order to increase the number of groups contracted and lower the price. It was also advantageous to opt for larger groups of 800 MW – which at that time were technically feasible and had recently been licensed in the U.S. – as well as the construction of two units per site.[28]

TABLE 1 ▪ *Specific cost (pts/kw net) for different strategies of contracting*

		Unit power	
Type	**Bidding strategy**	**500 MWe**	**800 MWe**
Fuel oil	1 site, two groups	9,000	–
Nuclear	1 site, first group	17,000	13,900
Nuclear	2 site, second group	14,400	12,100
Nuclear	1 site, two simultaneous groups	15,700	13,000
Nuclear	2 sites, four groups	13,900	11,600

Source: "Nota sobre los proyectos nucleares de Iberduero". A. ANAV, Box M33-A3-221.

At the same time, FECSA established contacts with Ortega Costa, the general director of Energy and Fuel (Ministry of Industry), who expressed his objections to a turnkey contract, arguing that it would leave the electricity company without any initiative during construction; as well as that there would be difficulties for the approval of technologies other than enriched uranium and light water plants. He also expressed concern about the lack of understanding between companies in Catalonia, which led to partial demand planning, fearing problems of matching the production of a large nuclear plant with market demand.[29]

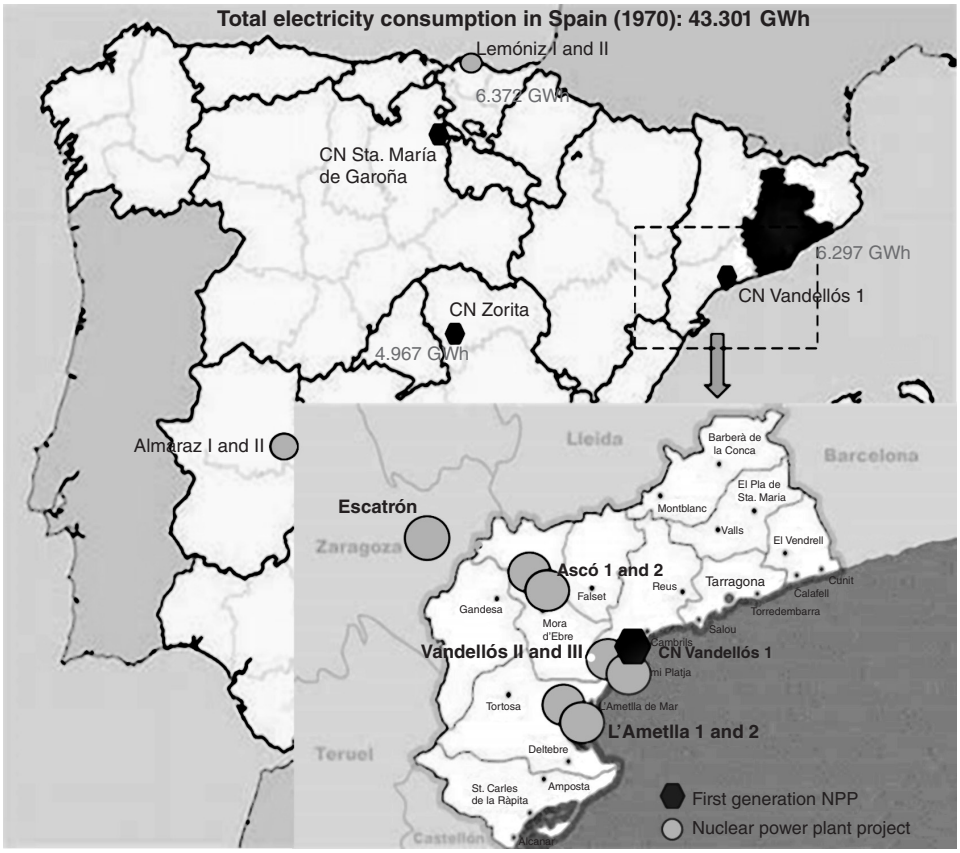
Pascual, technical secretary of the JEN, still suggested including in the tender the technology based on heavy water (in reference to the Siemens plant in Argentina (Atucha), although expressly stating that the decision should be taken based on economic criteria. In relation to the type of contract, it was indicated that turnkey contracts did not enjoy the sympathy of the Administration but, in his opinion, it would be possible to define a type of turnkey

28 The use of new alloys in the reactor vessel allowed to withstand the higher temperatures that were reached with higher powers.

29 "Entrevista de los señores Algueró y Garzarán de FECSA con el señor Ortega Costa, Subdirector General de Industrias de la Energía", March 4th, 1970. A. ANAV, Box M33-A3-221.

contract with greater technical participation of the company that was acceptable.[30]

FIGURE 3 ▪ *Location of operational or under-construction nuclear power plants in Spain in 1970, in relation to consumption centers, and the different nuclear projects in Catalonia*



Source: Own elaboration.

To exclude the option of heavy water, a comparative study of technologies was commissioned from the English firm Merz and Mc Lelan, together with Auxiesa.[31]

Meanwhile, to verify the design, independent studies were commissioned from the American firms Bechtel and NUS on the potential effects of radio

30 Note by Juan Algueró regarding a meeting with Pascual (JEN), April 16th, 1970. A. ANAV, Box M33-A3-221.

31 "Nota sobre los proyectos nucleares de Iberduero". A. ANAV, Box M33-A3-221.

nuclide emission into the Ebro as a result of the maximum accidental leak that could be postulated. These studies were delivered in September 1971.[32]

With this background, once the need for investment within the company was justified, the disposition of the land in the planned location secured and the disposition of the authorities explored, on 15 June 1970 FECSA requested authorization to install a nuclear power plant in Ascó (Tarragona), consisting of two identical units of 900 MW.[33] The project was exposed to public information by the Delegation of Industry of Tarragona through publication in the *BOE* and in the official gazette of the province. The estimated investment was 10,760 million pesetas.[34]

During the allegations period, several were received regarding the use of water. The Ebro Water Commission, the Eastern Pyrenees Water Commission and the General Secretariat of Hydraulic Works expressed their reservations about the possible impact on the existing project of an aqueduct for the supply of water to the city of Barcelona. The irrigation communities and various municipalities and individuals objected in relation to water intakes for irrigation or consumption.[35]

The most important claim for the subsequent evolution of the project was put forward by ENHER, based on two arguments. On the one hand, it argued that the installation of a plant with the projected power capacity meant monopolizing all the new power foreseen in the PEN for Catalonia, also producing a saturation of the market in off-peak hours. In that period, the demand could be met exclusively with the production of Ascó and Vandellós I, giving a clear dominant position to FECSA. On the other hand, the flow needed for the cooling plant would cause the use of extraordinary flows from the Mequinenza and Ribaroja reservoirs, managed by ENHER, and could mean the shutdown of its plants or a severe modification of its production regime in periods of low water levels.

Regarding the first objection, ENHER requested the opening of the ownership of the new plant to other companies in Catalonia based on their previous participation in the production of that *Zona* (in a model such as that followed in the constitution of TERBESA between ENHER and HECSA, or in Vandellós I). In relation to the second, it requested the reconsideration of the site, suggesting the location of Vandellós.[36]

32 Note by Juan Algueró to Riverola, October 1st, 1971. A. ANAV, Box M34-D3-1.

33 Although previous studies were conducted considering a power of 800 MW.

34 *BOE* n.185 of August 4th, 1970 and *Boletín Oficial de la Provincia de Tarragona* n. 17 of August 7th, 1970.

35 Felipe Lafita's (FECSA) answer to the received allegations related to the use of river Ebro water, November 4th, 1970, and other documents. A. ANAV, Box M34-D3-1.

36 Sirvent Dargent, Ignacio. Petition to the ministry of Industry, September 4th, 1970. A. ANAV, Box M34-D3-1.

At that time, the mayor of Ascó intervened to expedite the start of the works before MPs and representatives of the Administration on the basis that "[...] All the people and region are eagerly awaiting the start of the works of the nuclear power plant [...]".[37] This effort was made following the unanimous agreement of the Local Council of 14 July 1971, which reflected the dramatic situation of the municipality due to the fall in the price of land, motivated by poor harvests, and the fear of the emigration of its young people, urging the approval of the nuclear power plant project.

On 8 March 1972, FECSA and ENHER finally reached an agreement whereby both companies acknowledged having come "[...] to the awareness that it is desirable to establish a reasonable coordination of their future means of production".[38] In the immediate term, they agreed to share the project for the planned construction of a 500 MW fuel oil plant to serve a planned refinery in Tarragona, and share ownership of the planned plant in Ascó. In the same act, a letter was issued to the Ministry of Industry requesting that FECSA's application for authorization of June 1970 were considered signed by both companies.

As an immediate consequence, on 21 April the Ministry of Industry issued two prior authorizations, the first authorizing FECSA a first unit of 900 MW and the second to FECSA and ENHER for a second unit. This agreement was subsequently opened to HECSA and FHS, leaving the ownership of the second unit divided between FECSA and ENHER, with 40 percent each, HECSA with 15 percent and FHS with 5 percent.

At the same time, the tender for the main equipment was being carried out in a process coordinated with that of the Almaraz and Lemóniz power plants. In October 1971, FECSA analyzed the evaluation of the bids for Almaraz delivered by Combustion Engineering, General Electric, Kraftwerk Union and Westinghouse (see Table 2). The price (total and per kWh), the delivery times and the reliability of the supplier were assessed. Westinghouse turned out to be the one offering lower prices and, with General Electric, shorter delivery times.

The quality evaluation was made based on the experience of each of the builders, a criterion that together with the price placed Westinghouse, with 58 nuclear projects of a total capacity of 45,946 MWe, as the winner of the contest (see Table 3).

The absence of French firms in the tender may surprise, but it is necessary to take into account that in 1969 France had decided to abandon the technology of natural uranium-graphite gas (GCR) – the design of Vandellós I – and the construction of its first light water plant, Fessenheim, did not begin until

37 Letter by Jose Miguel Montaña, Ascó Mayor, to M.P. Fernando Bau Carpí, January 3rd, 1972. A. ANAV, Box M34-D3-1.

38 FECSA-ENHER joint communication to Minister of Industry, March 8th, 1972. AFE, reg. n. 8003.

TABLE 2 ▪ *Status of the comparison of offers for C.N. Almaraz in June 1971*

	Vendor	G.E.	KWU	C.E.	West.
Net MW		814.9	889.0	901.6	901.6
Almaraz 1	Equipment (million pts.)	12,074	11,659	11,129	10,908
	Interest (million pts.)	1,983	2,914	2,070	2,114
	Total offer	14,057	14,573	13,199	13,022
	Pts/kWe	17,250	16,393	14,640	14,443
	Cts/kWh	46.3	46.9	42.3	41.9
Almaraz 2	Equipment (million pts.)	11,280	10,323	10,238	10,129
	Interest (million pts.)	1,975	3,101	1,942	1,996
	Total offer	13,255	13,424	12,180	12,125
	Pts/kWe	16,266	15,100	13,509	13,448
	Cts/kWh	44.64	44.91	40.69	40.15
Total two units	**Equipment (million pts.)**	**23,354**	**21,982**	**21,367**	**21,037**
	Interest (million pts.)	3,958	6,015	4,012	4,110
	Total offer	27,312	27,997	25,379	25,147
	Pts/kWe	16,758	15,746	14,074	13,946
Equipment delivery time (weeks)		34	44	n. d.	34-36
Fuel cycle cost (cts/kWh)		11.0	12.1	11.7	11.4

Source: Comparison of offers Almaraz and Lemóniz, October 5th 1971. A. ANAV, Box M33-A3-227.

Note: n.d., no data available.

1971 (although Framatome was also explored, along with the Swedish ASEA, Switzerland's Gulf General Atomic Europe, Britain's British Nuclear Design and Construction and Babcock & Wilcox).[39]

Westinghouse's advantage was clear for the directors of the Ascó project; it remained to be verified that the conditions that this company offered for Ascó were equivalent to those offered for Almaraz and Lemóniz (see Table 4). Different options had been requested in the bids, so they were not immediately comparable, however, it was confirmed that Westinghouse maintained the prices given for Almaraz and Lemóniz.

On 17 November 1971, the contract for the supply of primary system, turbo-group and fuel equipment was tendered. The American firms Westinghouse, Combustion Engineering and General Electric were invited to tender, together with the German Kraftwerk Union (Granados García and Barrera Navarro 1983, p. 24; Caro 1995, p. 200); all the participants in the reference offer of Almaraz and Lemóniz.

39 Letters and explanatory notes by the mentioned companies. A. ANAV, Box M33-A3-222 (Vol. 936).

TABLE 3 ▪ *Plants in operation or construction in September 1971*

Vendor	Reactor type	No. of units			Total Power (MWe)
		Construction	Operation	Total	
General Electric	BWR	39	15	54	42,802
KWU (Siemens)	PWR	6	1	7	6,049
Combustion Eng.	PWR	13	1	14	12,919
Westinghouse	PWR	46	12	58	45,946

Source: Comparison between different proposals for supplying equipment a light-water reactor nuclear power plant. A. ANAV, Box M33-A3-227.

TABLE 4 ▪ *Analysis of the equivalence of the Westinghouse offers for Almaraz-Lemóniz and Ascó*

		Almaraz			Lemóniz		Ascó	
		Jun-71	Jan-72	Disc.	Jun-71	Jan-72	Feb-72	Disc.
Unit 1	NSSS	3,352	3,087	8%	3,162	3,278	3,055	7%
	Turbogroup	1,744	1,493	14%	1,494	1,627	1,508	7%
Unit 2	NSSS	3,298	3,086	6%	3,183	3,591	2,869	20%
	Turbogroup	1,995	1,714	14%	1,782	1,854	1,654	11%
Total		**10,389**	**9,380**	**9.7%**	**9,621**	**10,350**	**9,086**	**12.2%**

Source: Analysis of the equivalence of the Westinghouse offers for Almaraz-Lemóniz and Ascó. A. ANAV, Box M33-A3-227, and *Westinghouse* offert of March 14th, 1972. A.ANAV, Box M34-D3-8.
Note: the amounts are in millions of pesetas considering an exchange rate of 66 Pts/$.

After sending the formal request for quotations to Westinghouse, in November 1971, Juan Algueró sent a note to the management of FECSA urging negotiations for financing and sending the request for proposals to the other firms, "although it was only to pressure Westinghouse with the fear of a price reduction from General Electric".[40]

Some points of the request for quotations deserve to be highlighted.[41] In the first place, the convenience of aligning the projects with those of Almaraz and Lemóniz was pointed out (which allowed more advantageous prices), foreseeing as dates of entry into service in June 1977 and December 1978, six months after the corresponding groups of Lemóniz. Secondly, the power requested

40 Algueró, Juan. "Petición de ofertas a Westinghouse". A. ANAV, Box M34-D3-8.
41 Letter by FECSA to Westinghouse Proyectos Eléctricos on November 17th, 1971. A. ANAV, Box M34-D3-8.

was for 930 MW per unit (raising previous estimates). Finally, it was reported that the first group would be installed in Ascó, the second was open, being able to be installed in Ascó or Vandellós.

On 16 March 1972, the final offer by Westinghouse was received (see Table 5); North Anna plant was used as a design reference, just as for the offers submitted for Almaraz and Lemóniz. FECSA issued a letter of intent for the first group on 24 March; the second group would be engaged on 30 August 1972.

TABLE 5 ▪ *Prices from the Westinghouse offer, 14 March 1972*

	Unit 1	Unit 2
NSSS equipment and services		
$ USA	39,760,800	35,750,000
Pts.	430,850,000	509,950,000
Turbo-group equipment		3,086
$ USA	14,940,000	17,600,000
Pts.	521,650,000	492,250,000
Initial core		
$ per kg of metal U	106.86	98.33
Supervision		
$ USA	405,000	449,700
Pts.	8,500,000	10,040,000

Source: Westinghouse offer, March 14th, 1972. A.ANAV, Box M34-D3-8.

In the contract negotiation, the payment terms were agreed, consisting of 10 percent in cash and the remaining 90 percent financed, at an annual interest rate of 7 percent,[42] by the American export-import bank, Eximbank (45% directly and another 45% through financial guarantees with Chase Manhattan Bank).[43] The terms of the loan, for a maximum amount of 91.5 million dollars for the first group, contemplated the term of repayment of the credit for the equipment in 24 semiannual payments and that of the fuel in ten, both beginning on 30 September 1978.[44] Financing contracts with Eximbank were signed in February 1972 for the first unit and in November 1973 for the second.

42 The interest rate contained in the initial contract (7%) differs from that contained (6%) in the collection of data on Eximbank loans compiled in De la Torre and Rubio-Varas (2015, p. 148).

43 "Préstamo del Eximbank para financiar la central de Ascó". *ABC*, May 25th, 1973, p. 76.

44 Agreement between FECSA and Eximbank, Art. II, March 28th, 1972. A. ANAV, Box M34-D6- 26.

The conditions offered by Eximbank were similar (adjusting for the interest rates at the time) to those of the loans obtained for the construction of the Zorita and Santa María de Garoña plants and the other second-generation plants (Almaraz and Lemóniz).[45]

In May 1972, the engineering of the project was tendered, inviting to the process four Spanish firms (Auxiesa, Empresarios Agrupados, Informes y proyectos – INYPSA, and Sener) and three foreign firms (Overseas Bechtel Inc., Burns & Roe and Motor-Columbus – Burmont, and Gibbs & Hill). The American firm Overseas Bechtel Inc. (Bechtel) and the Spanish firms AUXIESA (of the INI) and INYPSA (of the FESA group) were the winners of the process. The engineering activity would be developed in Spain (Madrid and the site itself) under the framework of a joint organization, the Project Engineering Office (OIP), with a reference office (Bechtel) in the USA as support.

On 29 November 1972, the Spanish electricity companies with ongoing nuclear projects signed a contract with Denison Mines for the supply of uranium concentrates,[46] covering the needs of the Spanish power plants until 1977, and concluding with this signing the negotiations carried out by a committee created in May of the previous year by the National Subcommittee on Nuclear Fuels. This contract covered up to the first load of group 2.[47]

On 22 December, FECSA applied for the construction permit for the first unit (a year later it requested the construction permit for the second); in April of the following year the municipal building license was obtained for the first unit.[48] Also at that time, a request was made to the Ebro Water Commission for the reservation of flows for the cooling of the first group (a year later it would be requested for the second).

On 16 May 1974, FECSA obtained the construction authorization for the first unit,[49] with the requirement of reaching a 60 percent participation of the national industry on the total investment. For group 2 it was obtained on

45 De la Torre and Rubio-Varas (2015, p. 115-126) contains details of the relationship between Zorita and Eximbank. De la Torre and Rubio-Varas (2015, pp. 147-150) includes a list of the financing conditions by Eximbank of Spanish nuclear power plants.

46 "Comunicado de ENHER al director del Sector del Petróleo, Petroquímica, Gas y Electricidad del INI, comunicando la firma de los contratos de adquisición de concentrados de uranio y de servicios de conversión a hexafluoruro de uranio, adjudicados a Denison Mines de Canadá", November 30th, 1972. SEPI. Archivos INI. Caja 213. Archivo de Altos Cargos, Box. 00475-6.

47 At the beginning of 1977, it was contemplated that 25% of the uranium needs for the production of Spanish plants in 1985 would be met with national production, covering the rest with imports, as stated in Pascual Martínez (1977, p.11). In 1974, ENUSA renewed the contracts for the import of uranium concentrates, extending the guaranteed supply period until 1981, see Sánchez and López (2021, pp. 141-145).

48 The license of the second was framed in a conflict between the city council and the companies that exceeds the temporal scope of this work.

49 *BOE* n. 178, July 26th, 1974, pp. 15.486-15.487.

7 March 1975, with similar conditions.[50] From the first steps (March 1969) to the authorization to build the second group, six years had elapsed.

4. The third-generation projects

In the National Electricity Plan (PEN 69), with a horizon until 1981, the installed nuclear power capacity expected for 1981 was 8,500 MW. Francisco Pascual, in a paper entitled "Panorama of nuclear energy' presented in November 1969, estimated that it would continue to grow until reaching 70,000 MW in the year 2000 (see Table 6).

TABLE 6 ▪ *Forecast of evolution of nuclear power*

Year	Nuclear Power (MW)
1971	600
1975	2,500
1981	8,500
1985	17,000
2000	70,000

Source: 'Consideraciones sobre el programa nuclear español'. SEPI. Archivos INI. Box 430. Presidentes y otros altos cargos, 3.

It was highlighted in an INI internal note[51] that, to reach that power capacity in 1981, only Zorita (150 MW, already in operation), Santa María de Garoña (450 MW, about to become operative) and Vandellós I (about 500 MW, under construction) were available at that time. There were also plans to build a second group in Zorita (350 MW), and a first group in Almaraz (500 MW) and Lemóniz (500 MW),[52] with the expectation that they would be available in 1975.

At that time, the owner companies had plans for other two groups in Almaraz and one in Lemóniz (an additional 1,500 MW). The report warned that all the installed capacity added to that planned left a margin of about 4,500 MW pending to be specified to reach the expected power total in 1981.

As reported above, in June 1970, FECSA requested authorization for the erection in Ascó of two groups of 800 MW each. By then the Almaraz and Lemóniz projects already contemplated two units each, of 800 MW.

50 *BOE* n. 75, April 21th, 1975, pp. 8.361-8.363.

51 Note by mister Ruiz Castillejos "consideraciones sobre el programa nuclear español", September 10th, 1970. SEPI. Archivos INI. Box 430. Presidentes y otros altos cargos, 3.

52 At that time, it was the maximum power offered for light water nuclear plants, shortly after it went to powers above 800 MW.

In October 1970, shortly after FECSA launched its project in Ascó, ENHER contracted the Department of Geology and Seismic Engineering of the INI to produce a geological study of the maritime area of Vandellós to evaluate the construction of a nuclear power plant there.[53]

This initiative can be understood both in the sense that FECSA would desist from building two groups downstream of its reservoirs in the Ebro (as mentioned above), or as an initiative to promote its own plant. The latter option is supported by the fact that a feasibility plan for building a plant was being drawn up.

In line with this background, the management of the INI research service received, in March 1971, a report suggesting the installation of a nuclear power plant in Catalonia based on forecasts of growth in electricity consumption.[54] At that time, ENHER maintained the above-mentioned allegations regarding the FECSA project in Ascó. Consistent with these allegations, the report recommended that ownership (and production) of the proposed plant be shared by the four main producing companies in the area.

A month later, the management of ENHER approached Claudio Boada, president of the INI, with the request that the Institute's nuclear programs were analyzed and announcing that they had a preliminary project for the construction of a nuclear power plant.[55] A year later, as mentioned above, the collaboration agreement of the Catalan producers in the Ascó project was reached.

At the beginning of the decade, the increase in construction projects for new nuclear plants (in Spain and in the world), as well as the majority option for light water plants, whose operation required enriched uranium, increased expectations of demand for enrichment services. Until then, only the U.S. and the Soviet Union had uranium enrichment capabilities.

Talks were initiated for the construction of a European enrichment plant (by gaseous diffusion) between France, Italy, Sweden, Belgium and Spain. ENUSA acted as official Spanish representative, but the high dependence on energy (more than 50% of the cost of enrichment came from the cost of the electricity consumed in the process) led the electricity companies to actively participate in the project.

After the constitution of EURODIF the following year, Spain submitted two applications for the installation of the uranium enrichment plant, one in Cabo Cope (Murcia), sponsored by Hidroeléctrica Española, and another

53 Seismic report on Hospitalet del Infante (Tarragona), October 15th, 1970. A. ANAV, Box M26-C2-49.

54 "Nota recibida del sr. Kindelán sobre la conveniencia de que una nueva central nuclear en Cataluña sea abordada conjuntamente por las sociedades eléctricas con mercados en la Zona", March 1st, 1971. SEPI. Archivos INI. Box 430. Presidentes y otros altos cargos, 9.

55 Letter by Gonzalo Turell (ENHER president) to Claudio Boada (INI president), April 16th, 1971. SEPI. Archivos INI. Box 4781. Registro histórico del INI, exp. 230-146.

in the Ebro delta, in Camarles (Tarragona), sponsored by ENHER and FECSA. Although in ENHER's opinion, "with little enthusiasm on the part of FECSA".[56]

At a meeting held in April 1973 between EURODIF, ENUSA, FECSA and ENHER on the issue, the need for sufficient nuclear power in the area to guarantee an estimated annual consumption of 22,000 GWh was discussed,[57] This meant a power capacity of 2,500 MW with an estimate of about 8,700 operating hours, a production higher than that which four nuclear units of 800 MW could guarantee.

Other European countries (Great Britain, Holland and Germany) had founded another company, URENCO, for enrichment by centrifugation processes, whose production was considered feasible from 1985.[58] Therefore, there was an interest in the EURODIF plant becoming operational as soon as possible.[59]

An additional factor that conditioned the decisions of the companies regarding the planning of new electricity production plants at that time was the oil crisis of 1973. The blockade on oil exports produced a reduction in the availability of its derivatives on the world market of around 30 percent and an increase in the price, which went from 3.17 dollars a barrel to 12 dollars. The first reactions to this situation were to consider alternative sources to fuel oil that would guarantee electricity supply and price containment (Fig. 1), considering that demand would maintain its growth path.

Given the combined effect of the oil crisis, the potential need for power for the enrichment plant, the forecast of nuclear power not yet covered, as well as the estimates of demand growth, it is not surprising that the producers of Catalonia were, at the beginning of 1974, determined to equip themselves with a significant nuclear power base (see Table 7).

As a result of this effort, on 2 May 1974, coordinated applications were submitted for the construction of six 930 MW nuclear units: two requested by FECSA for a planned site in the municipality of L'Ametlla de Mar, two requested by an association formed by ENHER (54%), HECSA (28%), FHS (10%) and FECSA (8%) for a site in Vandellós and two others requested by Endesa (37.5%), ENHER (37.5%) and Eléctricas Reunidas de Zaragoza (25%) in Escatrón (Zaragoza). In addition, ENHER and Endesa were also studying

56 Minutes of the meeting held by ENHER and FECSA with EURODIF representatives in relation to a possible site in Ebro delta area for the European factory for uranium enrichment and its electrical supply, April 25th, 1973. SEPI. Archivos INI. Box 5148. Registro histórico del INI, 10.

57 Ibidem.

58 Brief by INI president to Jiménez Arana on several subjects, pp. 4-5, May, 7th, 1975. SEPI. Archivos INI. Box 190. Presidentes y otros altos cargos, exp. 393-0.

59 The lack of guarantees about the ability to have enough energy by that date and the worse financing conditions in Spain than in other countries (and surely also political considerations) decided the location of the plant in Tricastin (France).

TABLE 7 ▪ *Estimation of demand coverage by technologies*

Year/ MW	Max. Power peak	Reserve (6%)	Hydraulics	Coal	Nuclear	Fuel-oil	Endesa (*)	Surplus
1980	5,380	323	2,000	219	1,771	1,929	373	589
1981	5,951	357	2,150	219	2,509	1,929	373	872
1982	6,583	395	2,300	219	3,247	1,929	373	1,090
1983	7,278	437	2,450	219	3,247	1,929	373	503
1984	8,048	483	2,600	219	3,985	1,929	373	575
1985	8,899	534	2,750	219	4,723	1,929	373	561
1986	9,839	590	2,750	219	4,723	1,929	373	-435

Source: Study for application of the permit presented to the Delegation of Industry of Tarragona. A.ANAV, Box M26-C2-49.

the possibility of developing a two-unit nuclear project in the Cinca river basin (Chalamera).

FECSA informed the municipality of L'Ametlla de Mar of its intention to apply for the construction of a plant in its municipality. On 9 March, the city council unanimously approved a motion on the construction of the plant in which

> [...] it is considered of greater advantage than inconvenience for the locality, it is agreed, unanimously, to endorse the motion of the Mayor's Office and to this effect to see with satisfaction in principle the installation of the industrial location of reference [...] considering that it will be beneficial to the general interests of the population.[60]

But, when on the following 30 May the Official Gazette of the Province of Tarragona issued the request of FECSA to public information for allegations, neighborhood associations of the town had changed the opinion of the municipal corporation, which on 8 June decided to oppose the project.[61]

The neighborhood's rejection did not stop the activities. That same summer the previous geological studies of the terrain were completed, within a radius of about 15 kilometers from the center of the planned location, about 2.5 kilometers southwest of the town, in the coastal area located between the natural port of Estany d'en Gras and Estany Podrit.

60 Request by FECSA to the Ministry of Industry delegation of Tarragona (consideration), August 6th, 1974. A. ANAV, Box M33-A3-221.

61 From the head of electricity concessions to Mr Sanz: Brief of opposition of the C.N. of La Ametlla, July 26th, 1974. A. ANAV, Box M33-A3-221.

Also, in July 1974 FECSA signed a contract with the engineering company Burns & Roe de España (BRESA), with the support of its parent company, Burns & Roe Inc., for the elaboration of the project specification. This work lasted for much of the following year. In the bidding process, the provisions of the American Westinghouse, General Electric and the Swedish ASEA were explored.[62] Between July and August 1974, meetings were held with potential bidders and the document inviting bids was drawn up.[63]

However, by June 1974 there was already some fear that the projects might be delayed. For this reason, Endesa suggested to the INI that, given the urgency of putting the first group into service in 1982 and given that for the approval of Vandellós there seemed to be no problems, the management of Vandellós and Escatrón should be separated.[64] In April 1975, internal communications of the INI anticipated that the authorization of the first group of those requested in Vandellós was probable, but it was equally likely that the authorization for the groups in Escatrón would be significantly delayed.[65] Surely aware of this possibility, in May 1975, the mayor of Escatrón jointly with several local associations begged the president of the INI to expedite the project.[66]

The construction requests for the groups of L'Ametlla de Mar and Vandellós were accompanied by the mandatory study on forecasting the evolution of demand in Catalonia,[67] This report contemplated the saturation of hydraulic capacity and worked on the hypothesis of maintaining the production of classic thermal power plants, the planned increasing nuclear power production would support the expected increases in demand.

A sustained growth in demand of 11 percent was estimated and, consistently, the growth of demand for each of the four companies in the area, with the power being distributed based on the new groups to be installed (see Table 8). The first two groups were scheduled to initiate operation at the end of 1981.

For the preparation of the specification and analysis of the offers, a bidding process was initiated to which the following national firms were invited:

62 Specification C.N. L'Ametlla de Mar, weekly report, October 21st to 25th of 1974 and Specification C.N. L'Ametlla de Mar, monthly report Aug 1st, 74. A. ANAV, Box M33-A4-240.

63 "Invitación a ofertar el sistema nuclear de suministro de vapor (NSSS) para la central nuclear de la Ametlla de Mar". A. ANAV, Box M33-A5-421.

64 Letter by Fernando Lozano (ENDESA) to Jiménez Arana on the subject Escatrón Nuclear Power Plant, June 17th, 1974. SEPI. Archivos INI. Box 5267. Registro histórico del INI, exp. 230-49.

65 ENHER request to INI in order to take part in the constitution of "Asociación Centrales Nucleares Vandellós II y Vandellós III" and approve their statutes, April 22nd, 1974. SEPI. Archivos INI. Box 5498. Registro histórico del INI, exp. 230-10.

66 Telegram from the mayor of Escatrón to the INI president, May 24th, 1975, among others. SEPI. Archivos INI. Box 5456 y 5642. Registro histórico del INI, exp. 230, several documents.

67 Analysis of the needs to be covered in Catalonia, May 1974. A. ANAV, Box M26-C2-49.

Empresarios Agrupados, AUXIESA (in 1976 it was renamed INITEC, after the merger with EDES) and SENER. The foreign firms invited were Bechtel Power Co., Burns & Roe, Ebasco, Gibbs & Hill Inc., Gilbert Associates and NUS Corp. As a result of the process, the combination of AUXIESA and Bechtel was chosen for the process of specification and selection of the main equipment manufacturers and subsequently for the construction and commissioning phase.[68]

TABLE 8 ▪ *Estimation of demand coverage by companies**

Year	Demand	Increase	FECSA	ENHER	HECSA	FHS
1980	27,645		15,218	7,101	3,898	1,428
1981	30,699	11%	16,802	8,017	4,306	1,574
1982	34,089	11%	18,560	9,034	4,759	1,736
1983	37,839	11%	20,505	10,159	5,260	1,915
1984	42,001	11%	22,681	11,340	5,880	2,100
1985	46,621	11%	25,175	12,588	6,527	2,331
1986	51,750	11%	27,945	13,972	7,245	2,588

Plant	Power	Date	FECSA (%)	ENHER (%)	HECSA (%)	FHS (%)
Vandellós II	900	Sept 30, 1981	8	54	28	10
FECSA I	900	Dec 31, 1981	100			
Vandellós III	900	Jun 30,1984	8	54	28	10
FECSA II	900	Jun 30, 1985	100			

Source: Study for application of the permit presented to the Delegation of Industry of Tarragona. A.ANAV, Box M26-C2-49.

Note: FECSA I and FECSA II was the provisional name given to the groups envisaged in L'Ametlla de Mar.

** Depending on the expected demand for each company, the participation of each one in the new plants is agreed.*

The contracting of the new plants was proposed following a model similar to the one used in Ascó, that is, light water plant and contracting by "components", with mixed national-foreign engineering. This approach maintained the intention, already evident in the Ascó project, of obtaining synergies in the contract and in the subsequent construction.

Westinghouse, Framatome, Kraftwerk-Union and General Electric were invited to the bidding process for the main equipment, initiated in December 1974. Only the first two submitted bids. The evaluation of the bids was made

68 "Especificación para la selección y contratación de la ingeniería nacional y extranjera correspondiente a la fase de selección de los fabricantes del equipo principal para Vandellós y Escatrón". A. ANAV, Box M33-A4-240.

based on four groups of criteria: technical and security, prices, national participation, and financing.[69]

Westinghouse's technical offer applied in its bid standards issued by the U.S. Atomic Energy Commission until 1 January 1975, while Framatome's bid only used standards published until May 1973. In the interval between the two dates, some standards had been published that were already being applied in other plants under construction in Spain. In addition, the quality of the steam was superior in Westinghouse's offering, which meant a higher electrical power.

The price of Framatome's offer was, included financing, 40.8 percent higher than Westinghouse's offer. The latter also offered a Spanish stake in the equipment included in the contract (NSSS, turbo-group and first fuel load) of 33.1 percent, compared to 24.8 percent offered by Framatome. The financing, with a repayment in ten years from the start-up, was obtained with similar interest rates (including commissions) in both offers, of between 8.7 and 9.2 percent.

The magnitude of the difference between the offers of Westinghouse and Framatome for the construction of Vandellós II and the greater role of the promoters in the decision-making process made it impossible to reach compensatory political agreements such as those reached with France ten years earlier for the construction of Vandellós I.[70] On the other hand, the technological coherence between Vandellós II and the neighboring central areas of Ascó was an ostensible advantage in the subsequent construction period.

A particularly relevant topic was that of project design engineering. INI considered it a priority to hire a national company with the support of a foreign one. While Framatome proposed the hiring of its own engineering, which according to needs would hire different Spanish engineering. Westinghouse was open to any kind of formula.[71]

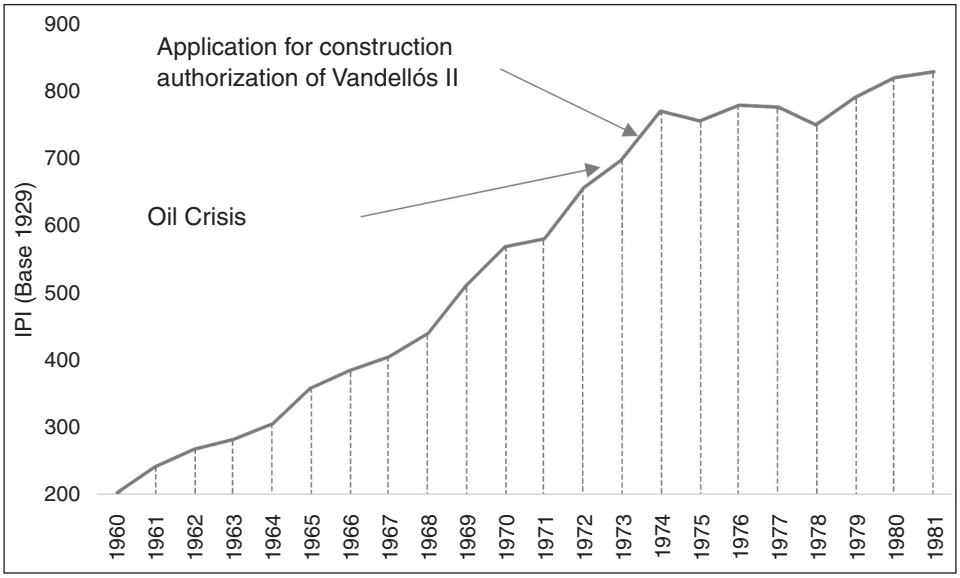
During the development of the project organization the boundary conditions began to change significantly. In the summer of 1975, when it was decided to award Westinghouse the contract for the main equipment for Vandellós II (and where required, for Vandellós III and Escatrón), the enrichment plant in Spain had already been discarded (Sánchez and López 2021, p. 146). With it, the need for 2,500 MW of power to supply it disappeared.

69 Brief by the sector on offer for nuclear power plants comparison. SEPI. Archivos INI. Box 190. Presidentes y otros altos cargos, exp. 393-7 y 9.

70 The higher cost of the French plant was offset by more favorable financing. See Marty and Sánchez (2000, p. 17), and also, Antonio. "La central de Vandellós". *La Vanguardia Española*, December 20th, 1973, p.30.

71 Despite the widespread opinion that it was Eximbank's financing policy that conditioned the option for American technology, see Rubio-Varas and De la Torre (2019, p. 136), it can be concluded from the available documentation on the evaluation of tenders for C.N. Vandellós II, as before for C.N. Ascó, that the decision was fundamentally influenced by technical and economic issues, the financial costs (or their availability) not representing a substantial difference between the different offers.

FIGURE 4 ▪ *Evolution of industrial production index (IPI) base 1929*



Source: Own elaboration from Carreras and Tafunell (2005), table 5.11.

On the other hand, the hypothesis that the oil crisis would affect fossil fuel prices without affecting industrial growth proved wrong. Faced with an industrial growth of around 10 percent per year sustained from 1960 to 1974 (the average IPI – industrial production index – in that period was 9.3% per year), in 1975 the industrial crisis began: that year the variation of the industrial production index was 2 percent. Electricity production, which was growing at a rate of 11 percent until 1973, fell to 2.4 percent in 1975. To these factors should be added the social and institutional uncertainties related to the change of regime at the end of that same year.

All the previous factors influenced the slowdown in the process of granting prior authorizations. They also led FECSA to request, by letter dated the 20 January 1976, that it be granted one of the first authorized groups to bring its production capacity into line with the trend on its market. This implied the exchange of the ownership coefficients of the planned Vandellós III, which would become 100 percent FECSA, in exchange for the management of one of the groups of L'Ametlla, whose exploitation would be held by the consortium of the four companies in the percentages established for Vandellós II.

These decisions meant, in fact (at the end of 1975), the paralysis of the projects in L'Ametlla de Mar and Escatrón. A paralysis caused by the new demand estimates contemplated in the previous studies of the new National Energy Plan (Pascual Martínez 1977, pp. 5-9).

On 27 February 1976, prior authorization was granted to ENHER (58%), HECSA (28%), FHS (10%) and FECSA (8%) to install a nuclear power plant of around 1,000 MW in the municipality of Vandellòs i l'Hospitalet de l'Infant.[72] In the same resolution, prior authorization was granted to FECSA to install an identical one on the same site. It provided for national participation in both projects to be at least 85 percent.

On 9 March 1977 the contract with Westinghouse was formalized and, simultaneously, another was signed with ENSA, acting as a subcontractor of Westinghouse, for the supply of the vessel, three steam generators, the presser, internal structure of the core and piping of the primary circuit.[73] The manufacture of the turbine was subcontracted with E.N. Bazán, while the large electrical equipment would be built in the Westinghouse facilities in Spain.

TABLE 9 ▪ *Financing scheme for C.N. Vandellós II (in millions of dollars)*

		Total M$	Total	EXIMBANK		FECSA	Wells Fargo
		161.00		Direct	Guaranteed	(Credit letter)	
			90.0%	50.6%	32.2%	7.2%	10.0%
FECSA	8%	12.88	11.59			11.59	1.29
ENHER	54%	86.94	78.25	48.06	30.59		8.69
HECSA	28%	45.08	40.57	24.44	15.55		4.51
FHS	10%	16.10	14.49	8.96	5.70		1.61
Total M$	**100%**	**161.00**	**144.90**	**81.47**	**51.84**	**11.59**	**16.10**

Source: Own elaboration based on data in "Eximbank Credit n. 6285 – Spain", and letter from Wells Fargo to CEOs of the companies that own the plant, November 15th, 1972. A. ANAV, Box M32-F5-140.

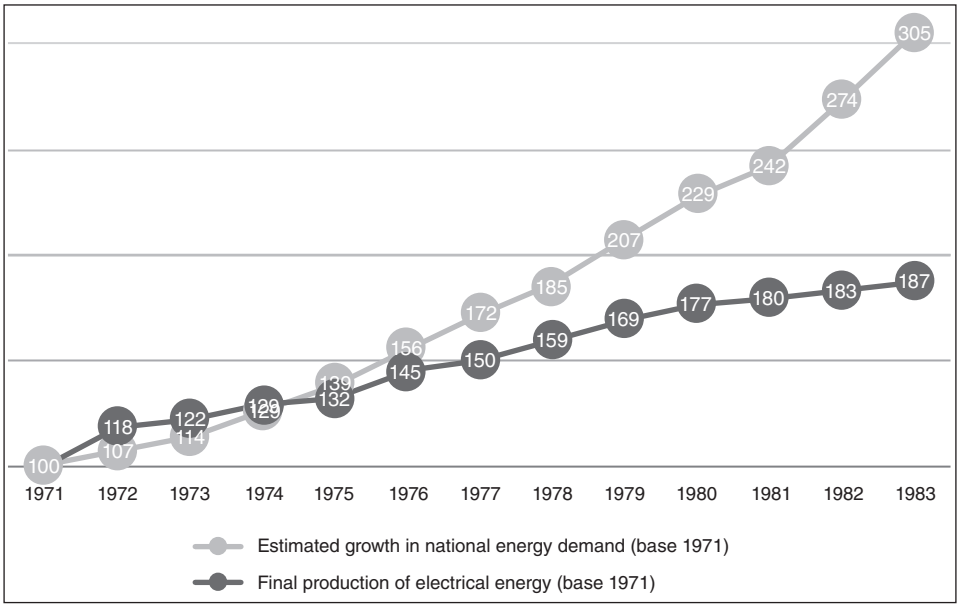
The next 25 April, the financing agreement for 90 percent of the dollar amount was formalized with Eximbank and with the Private Export Funding Corporation, PEFCO, based on a proposal from July of the previous year (see Table 9). The contract (Eximbank credit #6285) included direct financing of 50.6 percent and a guarantee for another 32.2 percent, corresponding to the amount borne by PEFCO.[74] FECSA was financed with a letter of credit for 7.2 percent, bringing the total of this financing to 90 percent of the payment of 161 million dollars. The loan, at 8 percent annual interest, was payable in 21 semi-annual payments beginning on 10 March 1983.

72 *BOE* n. 62, March 12th, 1976, pp. 5.172- 5.174.

73 Supplementary contract between Asociación Nuclear Vandellós, Westinghouse and ENSA. A. ANAV, Box M32-F5-144.

74 Certificate by Mr Agustín Escalza Gómez (ENHER board of administrator secretary), September 30th, 1977. A. ANAV, Box M32-F5-140.

FIGURE 5 ▪ *Expected evolution of national electricity demand (PEN 69) against annual demand (Index)*



Source: Own elaboration based on data from PEN 69 (*BOE* n. 199, August 20th, 1969, pp. 13.193-13.194) and its 1972 revision (*BOE* n. 181, July 29th, 1972, pp. 13.346-13.347) and UNESA. Electrical Statistical Report 1991.

Note: base index 1971.

For the financing of the remaining 10 percent, a contract was signed on 14 December with Wells Fargo Bank in London. The loan was payable over six years at a floating interest rate equivalent to Libor plus a 1.83 percent surcharge.

On 11 November of that year the design engineering contract was signed with INITEC.[75] The contract contemplated that the design engineering would be carried out in an integrated manner and jointly with Bechtel under a single organization; with INITEC acting as responsible to the owner companies of all engineering services, including those executed by Bechtel.

5. Conclusions

This article has explored the factors behind the expansion of large nuclear projects in Southern Europe by considering the case of Catalonia. In a small

75 "Contrato de prestación de servicios para la central nuclear de Vandellós II", November 11th, 1977. A. ANAV, Box M32-F6-147.

and fragmented market, such as the electricity market of Catalonia at the end of the 1960s, nuclear energy was for electricity companies an essential technology to meet the future needs of their market at competitive prices. In particular, in Catalonia all the proposed projects had plausible projections of demand evolution and economic estimates that justified their need.

Political intervention is not perceived in these projects to the extent to which it was present in the development of the first-generation projects.[76] American, French, German and Swedish manufacturers were invited to the bidding processes of the plants, following criteria of profitability and technical guarantee in the awards.

The decision to award the projects in Catalonia to Westinghouse was based on technical and economic criteria that were rigorously analyzed. The projects undertaken by this company in previous years, much more numerous than its European competitors, together with the lower cost of pressurized water technology compared to boiling water technology (offered by General Electric), gave this company a clear advantage over its competitors. In addition, the fact that the Almaraz and Lemóniz projects were taken as a reference allowed Westinghouse opportunities for economies of scale that its competitors lacked.

There is a certain tendency, both in the literature and within the nuclear sector, to overestimate the influence of public opinion on the decision to reduce the scope of the nuclear project. However, in most of the period analyzed (c. 1969–1977) no significant social opposition to the projects is evidenced in the documentation consulted.[77] On the contrary, the local corporations of Ascó, L'Ametlla de Mar and Escatrón initially expressed themselves in favor of its implementation.

It is from 1975 that the birth of neighborhood opposition to the project in L'Ametlla de Mar and Ascó is appreciated, but not in Escatrón. The massive demonstration of July 1977 in Bilbao (and the rest of those organized in Spain at the time), or the first ETA attack against the Lemóniz power station in June 1977, can hardly be considered to be behind the decisions to stop projects that were already interrupted, at least, 18 months before.[78]

76 Marty and Sánchez (2000), and De la Torre and Rubio Varas (2018, p.111), among others.

77 On the attention that the sector paid to environmental issues, through the Spanish Atomic Forum you can find an extensive account and references in Sánchez Vázquez (2010, pp. 178-187 and 142-143). In this work it is pointed out that "the accumulated baggage on the local experiences of the plants in operation since 1973 was seen positively from the nuclear point of view, and the general good acceptation was underlined due to the new employment opportunities and the path to development", op. cit. p. 184.

78 In May 1977, the State Antinuclear Coordination was created in Soria with the aim of channeling anti-nuclear movements, until then closely related to nationalist movements of independence bias, Sánchez Vázquez and Menéndez-Navarro (2015, p. 70).

After the oil crisis, it was mainly the estimates of demand growth, within the framework of the studies carried out for the preparation of the National Energy Plan since the end of 1975, which explain the paralysis of the L'Ametlla de Mar and Escatrón projects (Fig. 5).

Once the pretense of uranium self-sufficiency was abandoned (maintained by the JEN until the mid-1960s),[79] public intervention through the JEN and the Ministry of Industry focused on ensuring the safety of the new plants and achieving an increasing participation of the national industry in the projects. The percentage of participation of national engineering in the design reached 87.8 percent and the overall national participation was 88.1 percent in the Vandellós II project.[80]

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79 This could only be achieved by burning natural uranium, since enrichment (necessary for light water plants) was not within the reach of Spanish technology.

80 *Informe final de la construcción de C.N. Vandellós II*. June, 1988. A. ANAV, Box M27-F5-53.

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La difusió de l'energia nuclear al sud d'Europa: els grans projectes de Catalunya

Resum

El creixement esperat de la demanda elèctrica i la insuficiència de les fonts de producció tradicionals (basades en la producció hidroelèctrica i en centrals tèrmiques convencionals) van comportar que les empreses elèctriques a Catalunya projectessin la construcció de fins a vuit plantes nuclears que sumaven al voltant de 1.000 MW de potència. Els efectes sobre la demanda de la crisi del petroli van provocar una substancial reducció del projecte, que es va veure limitat a quatre unitats amb autorització prèvia a mitjan dècada del 1970. A diferència del que havia passat amb les centrals de primera generació, les empreses promotores van ser les principals protagonistes de les decisions relatives a ubicació, tecnologia i subministradors. Les empreses quedaven subjectes només a les preceptives autoritzacions, als mínims requerits de participació nacional i als principis de seguretat nuclear.

Paraules clau: energia nuclear, centrals de segona i tercera generació, C.N. Ascó, C.N. Vandellòs II, producció elèctrica.

Codis JEL: L94, N74, O13, Q41.

■

La difusión de la energía nuclear en el sur de Europa: los grandes proyectos de Cataluña

Resumen

El crecimiento esperado de la demanda eléctrica y la insuficiencia de las fuentes de producción tradicionales (basadas en la producción hidroeléctrica y en centrales térmicas convencionales) llevaron a que las empresas eléctricas en Cataluña proyectasen la construcción de hasta ocho plantas nucleares de alrededor de 1.000 MW de potencia. Los efectos de la crisis del petróleo sobre la demanda provocaron una sustancial reducción del proyecto, que se vio limitado a cuatro unidades con autorización previa a mediados de la década de 1970. A diferencia de lo ocurrido con las centrales de primera generación, las empresas promotoras fueron las principales protagonistas de las decisiones relacionadas con el emplazamiento, la tecnología y los suministradores, sujetas tan solo a las preceptivas autorizaciones, mínimos requeridos de participación nacional y principios de seguridad nuclear.

Palabras clave: energía nuclear, centrales de segunda y tercera generación, C.N. Ascó, C.N. Vandellós II, producción eléctrica.

Códigos JEL: L94, N74, O13, Q41.