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New exports, new rules? The early nuclear exports of Westinghouse and General Electric and atomic "learning by doing", c. 1955-1973

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1.- Introduction

In the early 1960s, very few industrialised countries could build a nuclear power plant. The technology for this purpose was extremely complex and, in the midst of the Cold War, necessarily controlled by States and by the International Atomic Energy Agency for reasons of defence and security. In the United States, Canada, the United Kingdom, France and the Soviet Union, the experimental phase then began to be overcome once the first atomic reactors could produce electricity connect them to the grid became functional. Two US companies dominated the industry of and the market for nuclear plant exports between 1960 and 1980. Westinghouse [WESCO] and General Electric [GE] had been the pioneers of a newly created technology that was difficult to replicate and very demanding in terms of human capital, knowledge and research. This technology was within the reach of very few companies.

Nevertheless, in August 1955, the First Conference on Peaceful Uses of Atomic Energy disseminated the idea that the future of humanity required nuclear development, which, among other effects, would eliminate energy dependence on fossil fuels. "Atoms for Peace" offered an opportunity to establish international contacts that would make it possible to transfer knowledge and fast technological learning to public and private companies, which is how Eisenhower's government communicated it[1]. Nuclear progress promised to quickly provide benefits to industrial, energy and finance companies. In 1962, the United States nuclear industry began its commercial operations on a grand scale beyond its borders. The American institutions had closed one phase of an effort towards the commercial development of nuclear electric energy. A massive injection of public funds paved the way for overcoming the technical difficulties of experimental reactors that produce electricity, although some large-scale engineering problems remained unsolved and experimental reactors were still far from being economically competitive. However, the American government and the pioneering industries of this new technology bet decisively on this business. The moment of making the investment

[1] Fisher (1997). Cohn (1990).

profitable had arrived, and in addition, the weaknesses in the US balance of payments necessitated an increase in external sales and placing capital in the external market.

In any case, incorporating nuclear plants into the energy supply of a country required industrial, business and engineering capacities that were very diverse concerning quality and security (including physics, chemistry and calculus as well as the use of new minerals and materials, together with previously unseen developments in electrical engineering and computation). In reality, only a small group of American firms could offer the essential components that form a nuclear plant and the engineering and consulting services for its construction. In fact, only two companies dominated the business (Table 1). This new source of energy required higher levels of investment and security than hydroelectric plants and conventional coal, gas and fuel oil power plants. Nuclear power involved building the plant and managing it over the course of a limited active life, in principle, of no more than forty years. The option chosen by the majority of nuclear power plants was to install light water reactors that consumed enriched uranium to produce the chain reaction. Until 1974, the United States maintained the Western monopoly of the market for nuclear fuel. That is, the most complex and expensive components were purchased in the lead country and in US currency, and obtaining abundant financing was essential. The nuclear kilowatt was more expensive, although the objective was to turn it into the "cheapest, most regular and safest" energy. Thus, the size of the economy and its energy needs, the expansive moment of the Golden Age and the finances of each country were determining factors for undertaking a civil programme to build nuclear plants.

Table 1.- Five largest US manufacturers of Nuclear plant equipment

(as of December 1975)

Company	Domestic	Foreign	Total	%
	(000 Mwe)			
Westinhouse	80,2	20,9	101,1	39%
General Electric	71,8	18,6	90,4	35%
Babcok&Wilcox	29,5		29,5	11%
Combustion Enenieering	34,7		34,7	13%
General Atomic	5,7		5,7	2%

Source:"Nuclear Power Plants—Export Orders Since 1974." Box H 116, Folder 524. Ex-Im Bank Archives.

Notes: commercial nuclear powered generating plants. The list is limited to those systems designend and supplied by US manufacturers. Experimental reactors, including AEC funded prototypes and rectors sold through foreing lisense agreements are excluded.

The United States acted accordingly. It was the leader of this process by fostering an ambitious programme of technology transfer on the part of the businesses

that had created this technology. In parallel, the United States used financial support from public and private banks that allowed buyers to front the costs of very expensive technology. In this context, the countries of the European Common Market, Japan and several industrial economies bet on the nuclear challenge. Their industrial and financial capacity prepared them for it. More surprising was that countries that were developing—that is, a priori, with fewer capabilities—decided and managed to be among the *firstcomers* of this energy that promised economic growth and prosperity. All of these countries developed nuclear power in the *gerschenkronian* sense of burning stages by importing these new and potent capital goods and by seeking foreign cooperation and technical assistance to progressively increase the degree of participation of the local industry. In slightly more than ten years and before the first oil crisis, business groups from a dozen countries had connected nuclear plants to the electric grid.

Spain was one of these countries and became one of the United States's major clients in this early phase of exporting nuclear plants. Because Spain had an economy relatively underdeveloped in the context of Western Europe and a fascist dictatorship, the goal of this article is twofold. First, we explain how Spain managed to became the principal nuclear client of Exim Bank, WESCO and GE, and we define the basic lines of the Spanish atomic programme. In the second section, we approach the business history of the first two nuclear plants that were built in record time to provide electricity to two of the most dynamic regions in the country. For this purpose, it seems essential to us to analyse the process of technological transference of WESCO and GE and how it affected the learning and management systems of the businesses in charge of the first nuclear facilities. Access to this technological innovation required a reliance on business people who were prepared to propel this business, with experts who knew how to manage it with guarantees and with financiers who managed the international credits. Thus, political, technological, economic, business and financial factors determined nuclear deployment in the early 1960s, and Spain was a testing ground of the first order.

2.- Market, State and Businesses in the Spanish Nuclear Programme, c. 1955-1972

To understand how Spain became an atomic pioneer in a short period of time, it is fundamental to consider the international scene and the evolution of the Franco regime from autarchy to a policy of economic development[2]. After 1948, Franco's government considered it a priority for political and economic reasons to lay the foundations of a scientific system that approached the development of nuclear technology. Accordingly, in 1951, the Spanish government created and financed the Nuclear Energy Board [*Junta de Energía Nuclear – JEN*]. Because Spain was under severe restrictions, in reality, the Cold War and the Western defence system activated the expectations that dictatorial Spain would enter the club of nuclear countries. The first step was taken by signing the Madrid Pacts in September 1953, through which Spain would receive economic, technical and military assistance from the United States. In exchange, the United States would build and use military bases on Spanish soil.

The next impetus was given by the "Atoms for Peace" programme, which was interpreted by the great Spanish electrical companies and their affiliated banks as the starting point for the nuclear race. Convinced that the business should belong to the

[2] De la Torre & Rubio-Varas (2015a).

private sector, in August 1955, the electric companies communicated this to General Franco and, months later, created two business consortia that divided the future Spanish nuclear market. Whilst Iberduero and Electra del Viesgo founded Centrales Nucleares del Norte SA [Nuclenor] and took the northern half of the country, Unión Eléctrica Madrileña [UEM], Hidroeléctrica Española and Sevillana de Electricidad joined forces in Centrales Nucleares SA [Cenusa] to take the central and southern zones. Implicitly, the third large piece of the Spanish electric map, Catalonia, remained under the control of the dominant firms in this region, although their alliance in Hispano-Francesa de Energía Nuclear SA [HIFRENSA] had to wait until the Vandellós I project in 1965. In fact, these accords among oligopolies replicated the zones of production and distribution of hydraulic and thermal energy that have been sanctioned by the management of Unidad Eléctrica SA [UNESA] since 1944. The existence of these large businesses that have already shown their capacity to develop an energy industry and that have shown an interest in nuclear power would be a pull factor for the American multinationals from the end of the 1950s. General Electric, for example, considered this capacity strategic, together with the existence of a local auxiliary industry that supplied pipelines, cables, valves, instrumentation or electric transformers[4]. The problem, however, was that in Spain, there was no nuclear industry as such, and the relative level of technological development in the country was very low. The nuclear industry had to be created practically from scratch.

Within the autarchy, the government considered that it could achieve this industry creation by combining the efforts of public bodies—the JEN and the companies of the National Industry Institute [*Instituto Nacional de Industria – INI*]—and private companies to forge an industrial alliance that also supplied future nuclear plants. By using American patents, this alliance meant trials at the laboratory scale with reactors that consumed natural uranium from the Spanish subsoil; this alliance also required the trust that the national industry would mature in the medium term. Thus, the first to access the American knowhow were the management of the JEN, because they developed a plan to exploit uranium ore. With the support of the United States Atomic Energy Commission [AEC], executives and technicians from the JEN visited the main laboratories and research companies in Chicago, Oak Ridge (Tennessee) and Pittsburgh, where they also attended training courses between 1954 and 1956. A result of this visit was the coordinated action among the Eisenhower Administration, General Electric, Exim Bank and the Spanish atomic agency to create an enriched uranium reactor that became functional in 1958 at the JEN facilities in Madrid.

Nevertheless, private initiative did not wait for progress among public agencies. Since its origins, in 1954, Spanish businessmen participated in the annual meeting of the Atomic Industrial Forum, an American consortium that brought together the industries for the peaceful uses of the atom, and in 1955, they demanded access to the nuclear energy business from the Head of State. Some of these businessmen were witnesses to this new industry and ended up being key players in the Spanish nuclear strategy. The Spanish engineers travelled with some frequency to the United States on trade missions and collaborated in the construction of thermal coal and fuel oil plants headed by American firms or in other large industrial projects. Thus, between 1948 and 1950, the Spanish TALGO project took engineer Jaime MacVeigh to some of the

[4] Kaynak & Wells (1990).

districts of the nuclear industry led by WESCO in Pennsylvania[5]. MacVeigh had travelled to manage the construction of the famous articulated train with American Car & Foundry. Upon his return to Madrid, he abandoned TALGO and was hired by the Banco Urquijo. MacVeigh went on to specialise in nuclear projects, convinced that they offered "the solution to Spain's electric problem". In December 1956, MacVeigh became part of the Spanish delegation that attended the Second International Conference of European Industries, held in New York, and in which the "economic, social and technical aspects of the use of nuclear energy" were discussed. The director for the Banco Hispano-Americano (Luis de Usera) and the delegate counsellor of Babcok & Wilcox Spain (Leandro J. Torróntegui, industrial engineer and another of the promoters of nuclear energy from Bilbao) were present, and they responded with identical interest, although they had travelled separately. In 1957, MacVeigh, as technical advisor and counsellor for Urquijo, developed a very long-term expansion strategy and collaborated in founding the nuclear engineering company Tecnatom. From this company, MacVeigh directed and led the project of the first Spanish nuclear plant on the Tajo river, at Zorita, with technology from WESCO. Together with the most significant executives of the electric companies, MacVeigh also participated in the Assessment Commission of Industrial Reactors at the JEN, where he established alliances with scientists, experts and businessmen[6].

From this position, this group of engineers and patrons attempted to influence the nuclear programme to rely on private capital in contrast with the people who maintained that nuclear plants should belong to the State. Well-connected to the Madrid business bourgeoisie and with direct contacts in the main decision-making mechanisms of the government, in late 1961, MacVeigh helped to create the Spanish Atomic Forum lobby and wrote a decisive confidential report to convince the politicians of the Ministry of Industry. In a country where "there is no nuclear industry" that has limited financial capacity, MacVeigh was convinced that for a short-term solution, it was necessary to import nuclear plants from the United States[7]. In the long term, this learning process would create the local industrial capacity to supply a very ambitious nuclear programme that included a network of plants and the fuel cycle. The JEN was thus relegated to a purely technical and regulatory role.

In fact, the arguments that ended up shifting the balance to the side of electricity sponsors brought them towards a policy of economic liberalisation that was conducted by the dictatorial government between 1959 and 1963. The policy of industrial development bet on modernising Spanish businesses' manufacturing capacities through access to technological capital and foreign business organisations. The nuclear plants synthesised this paradigm very well. The nuclear law of April 1964 established an objective that at least 40% of the facilities of every nuclear plant would be built by Spanish companies. At the time, the first two nuclear power generation projects—Zorita and Garoña—were very advanced, whereas the nuclear power projects of Irta and Vandellós were behind. Altogether, the four projects are inseparable from the expansion of the business of nuclear technology export and therefore from the international policies of two of the most relevant international associates of Franco's Spain, namely,

[5] In fact, in 1957, the first commercial nuclear energy plant in the United States was activated in Shippingport.[http://www.phmc.state.pa.us/portal/communities/pa-heritage/atoms-for-peace-pennsylvania.html] (8/04/2016).
[6] De la Torre & Rubio-Varas (2015b), and Romero de Pablos & Sánchez-Ron (2001). MacVeigh (1957).
[7] De la Torre & Rubio-Varas (2015a).

the United States and the France of the 5th Republic.

3.- The first-generation Nuclear Plants, 1964-1971

3.1. A model of "learning by doing"

The connection to the electric grid of the Zorita plant in 1968 and the Garoña plant in 1971 culminated in a history in which the governments and businesses on both sides of the Atlantic collaborated very closely. Due to its technological and financial complexity and how unprecedented the project was, all the implicated parts activated a learning process that contributed to consolidating a model of collaboration between the two countries in the medium term. The contracts of the Madrid Electric Union [*Unión Eléctrica Madrileña – UEM*] (a partner of Cenusa) and Nuclenor with the American nuclear giants—WESCO and GE—signified a before and after in the bet on alternative nuclear energy and in the maturation of an unprecedented industrial sector in Spain and that began to launch commercially in the United States. Consequently, the lessons learned were multiple. Similarly, the intergovernmental relationship and the role played by the public and private American banks are a genuine reflection of a foreign policy that demanded a disciplined division of roles among businessmen, experts and policymakers.

The electric companies that controlled the building of a plant had to assume multiple tasks. Among other tasks, they had to 1) obtain authorisations from the regulators who watched over the security and guaranteed the industrial facility, 2) negotiate patents and licenses, royalties, educational and training services for the engineers of the host country, 3) obtain credit under acceptable terms and 4) execute a project that was unprecedented and complex, which joined with guaranteed reactors, receptacles, refrigeration and fuel loading systems to produce commercial electricity.

The location that was chosen for both plants responded to several motivations. On the one hand, there was the proximity of two of the regions that were undergoing a demographic and economic explosion in the mid-twentieth century. These regions were the urban and industrial environment of the capital of Spain (Madrid), in the centre of the country, and in Gran Bilbao, on the Cantabrian coast (with branches towards Cantabria and Guipúzcoa). Since before and especially after the civil war, the demand for electricity in these regions had grown exponentially, and consequently, businesses had invested in a hydroelectric production infrastructure with a high-tension distribution that would become key for an efficient connection to the nuclear electricity grid[8]. On the other hand, the type of chosen reactors demanded regular and increased water consumption to guarantee their refrigeration; therefore, the plants were located next to two of the largest peninsular rivers—the Tajo and the Ebro—and in the proximity of reservoirs that belonged to the promoter businesses to assure reserve water during drought periods.

[8] Núñez (1995).

Table 2: Basic characteristics of the first-generation nuclear plants

Plant:	**CN ZORITA**	**CN STA. Mª GAROÑA**
Type of Project	"turnkey project"	"turnkey project"
Promoter	**Unión Eléctrica Madrileña**	**NUCLENOR (Iberduero y Electra Viesgo Sa)**
Technological Business	**WESTINGHOUSE Cº**	**GENERAL ELECTRIC Cº**
Potency	150 MW	460 MW
Reactor	PWR	BWR
Fuel	Enriched uranium	Enriched uranium
Location	Guadalajara	Burgos
River	Tajo	Ebro
Reservoir	Zorita	Sobrón and Cillaparleta
Electric Consumption Centre	**Madrid** (Urban and Industrial)	**Basque Country/Cantabria** (Urban and Industrial)
Distance to Consumption Centre	60 km	60 km
Principal Exterior Financing	EXIM BANK	EXIM BANK
Secondary Nacional Financing	CHASE MANHATTAN BANCO URQUIJO, HISPANO-AMERICANO	GETSCO VIZCAYA, BILBAO, ESPAÑOL DE CRÉDITO, CENTRAL AND SANTANDER
State Guarantee	YES	YES
Project Start	1961	1963
Prior Authorisation	1963	1965
State Authorisation	24/05/64	18/05/66
Work Start Date	1965	1967
Grid Connection Date	1968	1971

Source: De la Torre & Rubio-Varas (2016) and Nuclenor (vv.aa.)

The viability of both projects depended both on the efficacy of the foreign industrial partner and on the learning capacity of the Spanish partners. The "American friend" was unbeatable in technology and finances compared with the British, French and Germans. The contacts, counsel and offers of the principal American and British firms had been abundant in the previous phase[9]. However, other business factors came into play and explain why WESCO and GE imposed themselves on other offers in each case. The negotiations between both multinationals and the promoter businesses were part of their history. Although WESCO opened a trade delegation in Spain in 1901 and has provided motors to the suburban metropolitan area of Madrid since 1918, its industrial presence became more important later[10]. In 1930, WESCO became an investor and technological provider of CENEMESA, the factory for electric motors and transformers, with its seat in Cordoba and Erandio (Vizcaya), whose major shareholder was the Banco Urquijo, which, in turn, owned the UEM, the promoter of Zorita NPP

[9] Archivo Histórico del BBVA. Memorias Nuclenor, 1964 and 1965.
[10] Westinghouse Electric Corp. HSWP Archives, Series I, Box 31. Early W Operations abroad.

that obviously installed a WESCO reactor[11]. In the choice of the technological leader in Garoña we can also identify some pre-existing factors in favour of GE. First, the presence of General Electric on the Administrative Council of Iberduero since before the civil war. Second, the assistance contracts of GE to Iberduero for the construction of thermal plants financed with the resources of the Exim during the 1950s must have played a determining role[12]. In addition to the competitive advantage in nuclear material, it seems clear that the previously established business networks reinforced that the global direction of both projects would fall to these American firms. In Zorita, a *Power Water Reactor* (PWR) made by WESCO would be established, whereas in Garoña, a *Bowler Water Reactor* (BWR) by General Electric was chosen. These choices imposed the option of enriched uranium as fuel by leaving aside the natural uranium found in Spanish mines. Moreover, there was one significant difference: in the case of WESCO for Zorita, Spanish uranium was used that was sent to the United States for enrichment, whereas in the case of GE, the fuel was directly imported[13].

In both cases, and given the inexperience of the Spanish nuclear industry, the promoter businesses accepted the offer of projects of "turnkey contracts", which had just been launched in American nuclear projects in 1963. In fact, Zorita would become the first "turnkey contract" project that was successfully exported by the United States. The Nuclenor Memo of 1964 summarised this idea of "a unique contract that included all the facilities completed and functional". This global contractor "should subcontract in Spain the parts that our industry can provide with the high quality levels" that are required. Thus, "we will get a guarantee regarding the entire plant and its components", characteristics, costs and deadlines. The nuclear law established a local component of 40% of the total with an understanding that this percentage would fall upon "the engineering, teams and equipment, assembly and work"[14], that is, the part with the least amount of vanguard technology. At least the Spanish industry did not start from scratch because it had already developed techniques for mechanical and electrical assembly in conventional thermal plants. However, new processes had to be designed in civil engineering, financing, logistics and transport, as well as management and training for the specialised human team.

In MacVeigh's words, the nuclear challenge consisted of "improving, in general, their standards of construction and productivity"[15]. The purpose of the UEM was identical, namely, "to acquire practical experience before initiating massive nuclear energy production" from which the State and the private companies would benefit because in this way, "the knowledge would be disseminated". With the collaboration of the JEN and the training with American technicians "in assembly and exploitation", the training of qualified personnel started long before the work began. However, similarly, the learning path was essential for the nuclear experts from the United States. The Spanish plants found themselves among the first commercial plants exported by WESCO and GE, and the degree of participation of the local engineering, industry, logistics and services companies required cooperation by both sides. Moreover, the

[11] https://cordobapedia.wikanda.es/wiki/CENEMESA (26/07/2016).
[12] De la Torre & Rubio-Varas (2015a).
[13] This was one of the central negotiation points with the government. It was necessary to gain access to nuclear fuel "in the most economic conditions possible" (including credit for the plutonium produced) and "using the most advanced technique in the international market" without paying taxes. ABE, IEME, Secretaría, C. 139.
[14] AHBBVA, Memorias Nuclenor, 1964. Revista Nuclear, 1966 (5-7: pp. 257-8).
[15] De la Torre & Rubio-Varas (2015a).

"turnkey contract" also implied the invariability of the final agreed-upon price and strict deadlines for completion.

Ultimately, the "turnkey contracts" seemed to be the most suitable in this historical context to encourage a process of "learning by doing". However, the execution strategies were different for each plant. In the case of Zorita, WESCO trusted in and allowed the participation of the Spanish promoters. Perhaps the relationship of trust forged with MacVeigh in his trips to the United States and the reputation of his leadership convinced them that he should guide the project globally through a completely Spanish *ad hoc* company—the Tecnatom SA consultancy. However, in the example of Garoña, GE directly executed the entire project from start to finish. We do not know whether this action was due to a lack of confidence in the level of the local engineers or if this was their practice in all the projects that they built. In fact, this decision was coherent with the primary nature of this type of contract, even more so when dealing with technology that was very demanding in the quality of the processes of production, industrial property rights, personnel training and technical assistance. In any case, the two projects chose a model that they considered to be a "well-tested" technical and economic guarantee, and they avoided "spending on research, development or trials". This contractual modality facilitated the direct transfer of technology and laid the foundation for a global "learning by doing" process. The construction and set-up of the reactor implicated the development of a completely new logistics for Spanish engineering and for the multitude of businesses that must be subcontracted for very specific and specialised tasks.

The process of personnel training was similar in the two plants, with certain nuances of interest. In collaboration with the JEN, Tecnatom designed Zorita as a future learning centre for the nuclear sector. Zorita was the smallest commercial reactor, and as the first nuclear reactor, it was predestined to conduct this function. The American technicians from WESCO trained the Spaniards in situ in the different phases of launching and managing the plant. The learning included stays in Pittsburgh (Pennsylvania) and work sessions at the seat of the JEN in Madrid. In the case of Garoña, a plant that was triple the size of its rival, the technical curriculum was first studied in the trial reactor at the Engineering School of Bilbao and in the facilities of the JEN, especially in the nuclear plant that GE had built in Garigliano, Italy, a BWR of 150 MW that was operational beginning in 1964.

Regarding national participation, local companies identified very quickly the nuclear programme as an opportunity. The Spanish businesses that wanted to participate had to innovate in products, techniques, knowledge and management. The manufacturing of capital goods and industrial assembly similarly demanded engineering and counselling services on a large scale. Some of these firms were created at that time, and others that already existed adapted to the new challenge by diversifying their lines of production and strategic alliances with foreign companies[16]. This approach resolved the Spanish businesses' large insufficiencies of capital and knowledge.

3.2. Economic diplomacy and financing

However, without financing, a nuclear programme was unviable, and here, the

[16] De la Torre & Rubio-Varas (2015b).

role of governments was essential. The magnitude of each of these financial operations involved resorting to economic diplomacy. Globally, the internal problems of each partner had to be considered in terms of balance of payments and financial needs and the search for some reciprocity. This was something more than a trade and business operation that is based on solvency and the reputed ability to pay. For its strategic content, a nuclear programme had to come guaranteed and sustained by the political relationships between the States and by the fulfilment of a complex bureaucratic process[17].

Before travelling to the United States, the electric companies had to obtain authorisations from at least three ministries (Industry, Commerce and Treasury) that approved the industrial project of the plant (with the favourable security reports), the licences for importing the equipment and nuclear fuel, the assignation of US currency to acquire the equipment and services through the institution in charge of authorising currency movements (the Instituto Español de Moneda Extranjera -until 1973- or the Bank of Spain -from 1973 on) and the guarantees of the State and the fiscal exemptions for the American partners. Finally, the Council of Ministers authorised the operation. The ambassador and the trade office in Washington would act as spokespersons for the promoter businesses in each of the instances that the process required[18].

First, the supply agencies of the reactor and the fuel in Pittsburgh (Pennsylvania) and San José (California) had to be contacted, and the agreement had to be signed. Second, the approval of the State Department and the Atomic Energy Commission to access the enriched uranium was required, which in principle was not foreseen and had to be done for Zorita. Finally, credit had to be negotiated in Washington and New York with Exim Bank (for the purchase of American capital goods and fuel) and with the private banking consortia (for the components and services from third countries). From the beginning of these processes until the signing of the loans, the process usually lasted one year.

In the example of Garoña, the process to access Exim Bank was formally begun in September 1966, and the contract was not finalised until June 1967. The correspondence that was exchanged between the counsel delegate of Nuclenor, Manuel G. Cortines, and the sub-secretary of the Ministry of Commerce, Alfonso Osorio, synthesises the culmination of this process.

> "I write to you again to give you an account of how my paperwork to get the loan is going", "but this time, my news is very satisfactory". "Accompanied by [Juan Luis] Pan de Soraluce and [Enrique] Chavarri, [counsellors] from our Embassy, and by representatives of General Electric, we had a long conversation with two employees of the Bank [Exim], in which in principle, the main conditions for the loan were outlined. The next day (15 June), the Bank Council met, and after the meeting, they communicated their offer to us, to which I gave my approval in the name of NUCLENOR"[19].

[17] Areilza (1984: 85-98). Badel (2012). Rubio-Varas & De la Torre (2016).

[18] A "bureaucracy [that was] powerful, disciplined and well-lubricated in its interior working, with which it would maintain decisive daily contacts for our mission. The American diplomacy that I have known impressed me in general for its efficiency and seriousness in its mission and in the exercise of its function" Areilza (1984: 85).

[19] Cortines explained that the bank "is giving us a loan" that "covers all the components of the plant of American manufacture, including what they call 'manufacture' of the reactor core. [$37.7 at 6% and 0.5%

In fact, this protocol was obligatory for all the countries that were buying nuclear reactors, industrial plants of various types or commercial airplanes made in the United States[20]. The credit of the American public banks was very advantageous in these years; interest and amortisation were repaid with a waiting period of five years, that is, when the nuclear plant theoretically began producing and charging for electricity to repay the loans. In addition, the price of the money was less expensive than in the capital market. However, Exim Bank only covered the indebtedness for the purchase of American capital goods. This consignment could include investment in construction projects (buildings for the reactor, turbo generator and water pump), the mechanical and electrical assembly, technical assistance and personnel training services and the fuel charge that is processed with an American license in a European country. Financing the equipment and facilities of non-American origin was possible either by giving entrance to the large private banks with a seat in New York or by negotiating directly with the providing companies.

Chart 2: Initial exterior financing of the first generation Nuclear Plants

	CN Zorita (1964)			CN Garoña (1967)		
Banks	mill $ USA	Type of Interest	Time frame	mill $ USA	Type of Interest	Time frame
Exim Bank	24,5	5,5	1968-83	43,7	6	1970-84
Others*	6,0	6,5	1967-82	8,7	6	1970-75
A. Initial funding	30,5			52,4		
B. Final funding	41,0			90,0		
(A) in mill € 2010	267			436		

*Others: Chase Manhattan Bank and GETSCO.
Source: ABE, IEME, Operaciones financieras, Box.1885 y 1973. EXIM

For the Zorita plant, WESCO gained the support of Chase Manhattan Bank, whereas for the Garoña plant, GE provided the secondary credit to complete the purchase of enriched uranium and of some services by using its American headquarters and its subsidiary in Germany (GE Technical Services). In fact, the signing of the contract with GE at the end of 1965 meant that Nuclenor would extend promissory notes for an unusual figure in Spain and equivalent to what Exim Bank would end up providing. Perhaps for this reason, Nuclenor resorted to a consortium of five of the most important private banks (Bilbao, Vizcaya, Santander, Español de Crédito and Central), with which Iberduero and Electra del Viesgo were historically related. For its part, the guarantees and domestic loans of Zorita corresponded to the banking group of Urquijo

commission on unused funds]. The repayment will begin six months after the start-up of the plant, which is equivalent to a moratorium of three years and which will be extended for a period of 15 years". A second loan of $6.5 that "covers the cost of the enrichment of the uranium, in analogous conditions to the previous one, including in the moratorium, but with five years of repayment". "For both the Bank requires a bank or Spanish State guarantee". ABE, IEME, Control de Datos, Box 1973. Carta de 26/6/67. Chavarri had been Head of the Office for American Help in the Ministry of Commerce in Madrid (ABC, 3/1/58).

[20] Cortines himself indicated that the conditions of credit "are frankly the best that could be obtained. What's more, I am convinced that they are better than those they have conceded for similar suppliers in other countries, for example, Japan, and I am sure that this is due to the extremely efficient management in the Ministry of Commerce, in Foreign Financing and in our Embassy". ABE, IEME, Control de Datos, Box 1973. De la Torre & Rubio-Varas (2015a).

and Hispano-Americano, which were shareholders of the Unión Eléctrica Madrileña and, in turn, were well connected to Chase. The electro-financial oligopoly worked at full capacity.

Chart 3.- Size, cost per MW and distribution of the investment in the Nuclear Plants of Zorita and Garoña (in millions of US$ and percentages)

	CN Zorita (1964-68)		CN Garoña (1967-71)	
	mill $ USA	%	mill $ USA	%
Power	150 MW		460 MW	
Cost/MW	0,20		0,11	
Initial funding				
USA Equipment	19,0	62,3	26,2	50,1
Fuel	5,5	18,0	18,7	35,7
Services	6,0	19,7	7,4	14,2
Total	30,5	100,0	52,4	100,0

Source: ABE, IEME, Operaciones financieras, Boxes 1885 and 1973.

4.- Some conclusions

The beginning of the 1970s was the greatest expression of Spanish nuclear optimism. In little more than a decade, the first two nuclear plants supplied electricity, and another two were underway, while dozens were planned and fed the fantasy of accelerated development. The so-called "economic miracle" of Spain took the form of a "nuclear miracle". A developing country had situated itself among the Western nuclear vanguard and designed a strategy that would reduce its energy dependence on coal and petroleum. The iron triangle that was forged among the government, the experts and the businessmen had worked. Between 1964 and 1974, the demand for electricity had tripled, and the sector could respond on the supply side. The alliance of the private promoters with WESCO and GE had accelerated "learning by doing". Everything seemed possible.

In fact, the National Energy Plan of 1969, which was revised in 1971, again foresaw a threefold growth in demand and consequently set as an objective the nuclearisation of the country to install 21,000 MW before 1983. Each year, at a minimum, contracts would be signed for two new nuclear plants. In addition, the public sector bet on creating companies that could produce fuel for all of these plants. The industrial policy continued to favour the formation of business consortia that would increase the capacity for manufacturing nuclear equipment by learning from foreign partners. At the end of 1972, the INI founded the National Uranium Company [*Empresa Nacional del Uranio – Enusa*] to manufacture fuel elements and simultaneously facilitated the creation of Nuclear Machinery [*Equipamientos Nucleares SA – Ensa*] to build the receptacles and the steam generators that were required for future plants. Enusa immediately bought the joint technical assistance of the two firms with the greatest international experience. WESCO manufactured 60% of the fuel consumed in the world by the PWR reactors, and GE supplied 70% of the enriched uranium for the

BWR[21]. These contracts, in turn, advanced the strategy of the engineering and consulting firms to grow, and the industry saw its business volume multiplied.

In fact, this lesson had been learned from the first generation of nuclear plants in Spain and in other countries. An editorial of *Nuclear Engineering International* in 1972 summarised it: "naturally, a country wants, as much as possible, the equipment for the plants supplied by overseas suppliers to be produced by its own industry". The companies should be able to produce a continuous series of nuclear components in a market that was plainly thriving. In Zorita, national participation reached 36% of the total, and in Garoña and Vandellós, it exceeded 39%. For Irta, there was hope to reach 45% participation in capital goods and 55% in engineering. Nevertheless, the dimensions that the Spanish nuclear programme would acquire—more than 20 projected plants—would not delay the testing of the industrial and financial capacities of the companies that owned the nuclear plants.

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