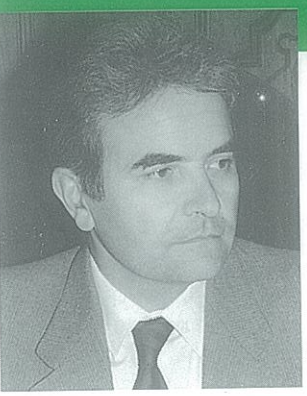


Adolfo GARCIA RODRIGUEZ has a doctorate of engineering from ICAI. He started working in the nuclear field in 1965, as the utility's representative in charge at the construction site of José Cabrera Nuclear Power Plant. He joined Empresarios Agrupados when it was incorporated in 1971. Has has been general director of Empresarios Agrupados since 1977.

THE ROLE OF GOOD MANAGEMENT IN NUCLEAR POWER PLANT CONSTRUCTION AND OPERATION (*)

A. GARCIA RODRIGUEZ

First I will start with an introduction to explain something as obvious as the importance of good management; or more specifically, why good management —vital to the success of any human activity— is especially important in the nuclear field. After that I will describe how we organized the nuclear program in my country, why, and what the present situation is. I will then go on to discuss the experience gained in different areas of activity —engineering and design, equipment manufacturing, construction, and operation— to finish with an analysis of the lessons learned in terms of the nuclear programs in general.

Let me now try to justify the title of my presentation which I would like to introduce with a brief history of nuclear power.

It was just over half a century ago when the work of different European scientific teams culminated in the splitting of a uranium nucleus by a neutron. The honor was bestowed on Professor Otto Hahn and his team from Berlin, and the date was between the end of 1938 and the beginning of 1939, as you all know.

The perspective of this half century confirms that the great significance of this discovery was immediately recognized, but the difficulties for its complete use were underestimated for many years. However, it is surprising the speed with which the applications derived from that initial experience have developed. In 1953, the program "Atoms for Peace" was launched with the idea that a new source of energy which was abundant, safe, reliable and extremely economical was immediately available to mankind for peaceful applications. During that same decade of the '50s, the first commercial nuclear reactors were constructed for power generation in different countries.

I wish to highlight the fact that a sector as traditionally conservative as the electrical one already considered this alternative sufficiently proven during the '60s. In fact, in the USA in that decade, the number of units contracted grew continuously, as did the unit size —increasing within a short time from 300 MW to 800 and 1,200 MW. Something similar was occurring in Europe. Spain —a politically and economically isolated country at that time— connected its first nuclear power plant to the grid in 1968.

It is a fact —we now recognize— that complete technological development took place almost in pavallel with the construction of the facilities. In the words of Admiral Rickover, progenitor of the American Nuclear Naval Propulsion Program, "tha rate of development and constrution of new plants offered little chance to profit from experience in projects under way in benefit of those which were to follow".

But the situation changed drastically

(*) *This conference was presented by Adolfo García Rodríguez at ENC'90.*

throughout the following decade, first in the USA and then in most of the remaining Western countries.

Completely in parallel with the construction of many nuclear power plants during the '70s, a rigorous regulatory process was developed in the USA, of which is it worth recalling some of the most important milestones:

- In 1969, the Atomic Energy Commission (AEC) published 10CFR50 Appendix B, "Quality Assurance Criteria for Nuclear Power Plants".
- In 1970, the AEC started publishing the Safety Guides, which were transformed into Regulatory Guides from 1975 when the Nuclear Regulatory Commission (NRC) was constituted. The publication in 1972 of Safety Guide 1.28, establishing an acceptable method to implement this concept in engineering and construction, had a considerable impact on requirements, documentation and, in short, on the effort to be made in these areas of activity.
- During these initial years of regulatory activity, a series of new requirements and criteria was introduced which had a big impact on projects, among which it is worth highlighting 10CFR50, App. K (ECCS), WASH-1270 (ATWS), Reg. Guide 1.75 (Physical Segregation of Electrical Systems), BTP 9.5-1 (Fire Protection), Reg. Guide 8.8 (ALARA), NUREG 588 (Environmental Qualification), and Reg. Guide 1.100 (Seismic Qualification of Electrical Equipment).
- In 1978, revision 3 of Regulatory Guide 1.70 was published, which substantially affected the structure and content of Safety Reports.
- The TMI accident in March 1979 had a considerable impact on different aspects of the safety criteria applicable to nuclear power plants, originating new requirements that have been progressively appearing since 1980.

It may be said that the conceptual design of water reactors has changed little in the past twenty-five years. Basic criteria of in-depth defense and of low-probability accidents have also remained unchanged. However, new acceptability criteria contained in the regulations have had a considerable impact. This impact has had a dramatic effect on the physical volume of the facilities, on the requirements with which components must comply, on studies to be performed, on the documentation and, finally, on the project schedule and overall plant cost.

According to the data bank of Ramesh N. Budwani published in the Power Engineering magazine, plant engineering —including project engineering and design, equipment procurement, field detail design, and plant startup support engineering— has risen in the USA from 1.7 - 10^6 m-h estimated in 1971 to 10.9 $\times 10^6$ m-h during 1982-83. With respect to construction, in the USA 5.3 $\times$ 10^6 m-h were estimated for direct work —craft— for a nuclear unit of around 1,000 MW in 1970-72, a quantity that rose to 31.5 $\times$ 10^6 m-h in estimates for 1982-83.

The consequence of this fact is that construction of tailor-made nuclear plants has become an extremely complex, costly task that requires an extended execution period, the whole thing involving a considerable contingency factor. These circumstances explain why the quality of management has a decisive influence on the success of these projects. Analysis of economic data banks in the USA relative to nuclear plants of the same type and generation offers sufficient examples. The situation has been similar in other countries, though specific information is more restricted. What is clear is that we have to solve a problem that requires something more than the implementation of fine management skills at project level. But this is not going to be a simple task. I will come back to this point later.

SCOPE OF WORK OF THE A/E

Head Office	Manhours x 10^6
Project Engineering & Design	5
Equipment Procurement	0.5
Site	
Contruction Management	2.5
Field Detail Design	1.5
Testing & Startup Mgt	0.5
Total	10 Million

THE NUCLEAR PROGRAM IN SPAIN

I am now going to explain how and in what context the nuclear program has been developed in Spain, indicating the basic principles that have been followed.

The Electrical Sector in Spain is, in the main, private and basically constituted by eight independent companies that generate and distribute energy. Red Eléctrica, a company with 51 % public participation which is the owner of the high-voltage network, coordinates and regulates the electric system as a whole.

Through the National Energy Plan (PEN), the Ministry of Industry and Energy plans the construction of new generating units —nuclear, fossil-fired and hydraulic. The PEN is subject to approval by Parliament.

Within the provisions of the PEN, each electric utility company selects the type and characteristics of its power generating plants. Nevertheless, in practice, our nuclear program has been focussed on light water reactors of W, GE and KWU technology.

A local participation of 85 % in the overall investment of the latest nuclear plants has been achieved in spite of contracting the NSSS to foreign suppliers. The main equipment however, including the reactor vessel and steam generators, is manufactured in Spain.

We have nine light water nuclear units —PWR and BWR— in commercial operation. One graphite-gas reactor has been paralyzed and will be decommissioned, and a further five —PWR and BWR— are in different phases of construction, but detained by a nuclear moratorium imposed by the Government in 1983. In addition, there are two other units with preliminary construction permits which are also affected by the moratorium.

On a comparative basis with other countries, our nuclear program could be considered on the whole as a success, with the exception of the investments made in plants whose completion has been paralyzed. Local industry has undergone rapid training and a favorable spin-off effect on other non-nuclear activities. Construction periods and execution costs that compare favorably with similar contemporary facilities in other countries have been achieved. Satisfac-

tory operating experience has also been gained. The nuclear plants as a whole reached a load factor of around 80 % during 1987, 88 and 89.

PROJECT ORGANIZATION

I am now going to discuss the way in which project execution has been organized in Spain; it has, after all, been one of the factors which have most favored industrial training.

It is well known that there are two basic formulas for nuclear project management —"turnkey" and "by components"— of which, in practice, there are numerous variants.

The "turnkey" approach has the advantage of placing Project execution in the hands of a highly professional organization —at least theoretically— with past experience in several other similar projects, although this is only true within a stabilized regulating environment. On the other hand, use of the formula "by components" places the main role of the Project in the hands of the Owner's organization, with the support of an Architect-Engineer. In this case, if the regulatory system is not stable, which has been the case in almost all countries, the Project can be progressively adapted to new requirements without a confrontation of economic interests between the Owner and the Contractor. It unfortunately favors the tendency towards tailor-made Projects to the detriment of standardization. Moreover, in many cases because it is the first nuclear project being undertaken, the Owner's organization lacks sufficient previous experience. The advantage derived from repetitive experience when using the "by components" approach can be maintained through the figure of the A/E, who often assumes a role similar to that of the Contractor in "turnkey" projects, although this role is only functional. The success of this scheme stems from knowing how to find a balanced distribution between the functions of the Owner and those of the A/E's organization, as well as good harmony between both based on mutual common interests and objectives.

As of 1971, the 'turnkey" system was abandoned in Spain in favor of that "by components", which has since been used in all the projects, assigning a most significant role to the A/E with a criterion similar to that applied in the USA. The equipment has been purchased component by component, avoiding contracting by large packages as has been customary in other European countries. One reason for this was the absence of large industrial companies with the capacity to globally manage such packages. Nevertheless, we had the industrial basis necessary to undertake the manufacture of isolated nuclear components.

NUCLEAR POWER PROJECT QUANTITIES (USA)

	Man-hours x 10^6	
	1971	1983
Plant Engineering	1.7	10.9
Plant Construction	5.3	31.5

A plan like the one described favored the growth of large A/E organizations with relevant means and increasing experience in different types of reactors. For example, Empresarios Agrupados' human resources in 1985 reached 2,600 of which half were university graduates. It participated as A/E with responsibility over all project areas, i.e. engineering and design, equipment procurement, site management, testing and operation support at nuclear power plants of W, KWU and GE technologies. This long and varied experience has enabled it to work in other countries, including the USA, Italy, Mexico, Brazil, etc., and to collaborate widely in international tenders in consortium with several main supliers.

The system followed in Spain, which consisted as I have explained in contracting the services of an A/E to assist the Owner of the Plant in developing the Project using a "by components" approach, had certain significant advantages:

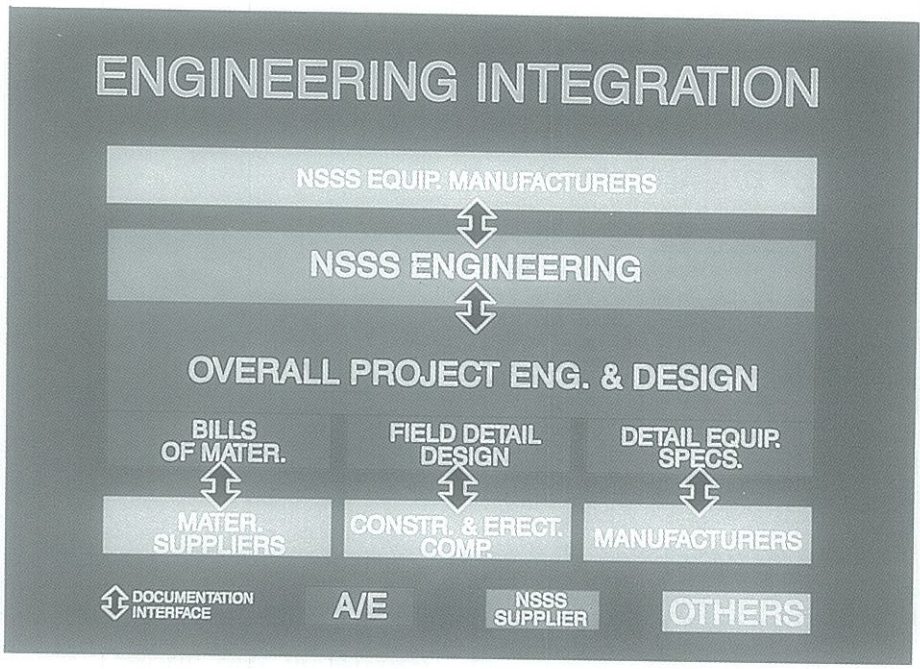
- Development of the A/E's enabled the concentration of a large volume of technical resources on these organizations and the rapid assimilation of know-how on most of the project areas. Training was carried out alongside execution of the projects, involving very limited investments.
- The A/E supported progressive involvement of the industry in the manufacture of nuclear components.
- The A/E complemented existing construction capacities through site management, which enabled complete participation of the local contractors right from the start.
- It was possible to undertake engineering and design of the entire project from basic engineering to field detail design in an integrated way, through a single organization, with homogenous procedures, thereby ensuring the necessary coherence and quality.
- Comprehensive and integrated preparation of engineering and design facilitated their computerization through CAD/CAE systems which incorporate configuration management techniques.
- The problems arising from fluctuations in the nuclear sector work load were not as serious in engineering orgnizations as in other undertakings. It was easier to reassign resources to other activities within a process of diversification or to foster the transfer of qualified technicians to other industrial areas. This process, which has taken place in Spain during recent years and affected thousands of qualified personnel, has had a favorable effect on industry in general, having evolved in the context of a large demand for engineers and technicians.

The manufacture of most of the components for the nuclear industry was undertaken in Spain in the context described, by way of rapid and progressive qualification of the existing industry. This can be considered a very positive experience. As an exception to this, Equipos Nucleares (ENSA) was created for the manufacture of main equipment —reactor vessels, steam generators, etc., and ENUSA, for the nuclear fuel. These two companies heve successfully proved their competence although, however, as in many been considerably reduced, in turn resulting in lower work load prospects.

In the area of industrial services, including architect-engineering, construction companies and others, capacities in the nuclear field were also created through the diversification and training of existing companies. An exception to the rule is the case of TECNATOM, an organization promoted by various electric utilities, which carries out training of operators and inservice inspections —fields in which it has reached an interesting level of specialization. The experience achieved in this area can also be considered as positive.

Power plant operation is also favorable, as evidenced by the high load factor and high availability of the nuclear plants I referred to earlier. It is a generally acknowledged fact that successful operation depends to a larger degree on the effectiveness of plant operation and maintenance personnel and, consequently, on good management, than on any other factor. Commercial operation in most Spanish nuclear plants falls under the responsibility of autonomous organizations, established by two or more joint electric utility owners of the plants. The support they require is obtained from the industry in general: architect-engineers, TECNATOM, various services companies and, on a small scale, from the original Main Suppliers. This is a pattern which functions satisfactorily.

The question may be posed as to why, in a reasonably autonomous context such as that described, a Systems Company responsible under licence for the NSSS has not been created. The subject has been considered several times with favorable and contradictory opinions. Personally, I have been, and still am, opposed to this initiative, for various reasons. In the nuclear field, it is increasingly important to promote full international collaboration as far as possible. In our case, we have maintained a policy of diversification and free competition within reasonable limits. Without needing to have a Spanish NSSS Supplier, we have achieved a creditable level of qualification and 85 % of local participation in the total industrial investment in our power plants. The lack of an indigenous NSSS Supplier, far from hindering our participation in foreign projects, has facilitated our involvement in various options in most of the international project tenders in recent years. I believe that with this policy we have avoided the temptation of autarchy, nor recommendable in any case in the nuclear field, even less so in ours, in view of the relatively low economic weight we bear in the group of industrialized countries.



LESSONS LEARNT

At the present time, in Spain —as in other countries— we still have a certain overcapacity in power generation. However, between 1995 and 2000 we should be connecting a further 7,000 MW to the grid and another 7,000 MW should be under construction. Since our indigenous, hydroelectric and coal resources have been exploited almost to the maximum, we are left with only three options —imported coal, nuclear energy, and the importation of electrical power from France. It seems difficult in these circumstances to think we can do without the nuclear option.

It would be as well, therefore, to reflect on which are the problems and what could be their solution. The problems obviously arise from the increasing cost of nuclear plants and a largely unfavorable public opinion.

It is evident that both problems can only be resolved within the context of a firm political determination to do so. There is nothing that either the industry or we the professionals can do if this will does not exist. But the situation is even more complex in that it also requires extensive international collaboration.

I referred before to the lack of standardization in many in the past. This is the most important lesson: we have to undertake the standardization of nuclear plants, but we have to do it within an international context; only in this way can costs be reduced and public credibility gained. But this involves decisions that are not only of a technical, but also of an institutional nature.

Al present, the regulatory systems existing in many countries do not guarantee actual stability of requirements, nor do they allow licensing standardized plant designs —this being the case in Spain. There is also a lack of uniform safety requirements and design criteria of an international nature which represents great difficulty for cooperation among countries.

As you know, a process of standardization open to international cooperation has been undertaken in the USA and it appears to be progressing. But there are still significant problems to be resolved. They refer to the actual concept of standardization. One such problem is the degree of detail that should be reached in the design to obtain design certification by the NRC. But there is also the problem of how to achieve true standardization in spite of the modifications that would have to be introduced from one plant to another built by different companies and maybe in various countries. Standard designs should be undertaken as such from the basic conception to the detail design, and it will later be necessary to maintain strict discipline in their application to each site. What is more, standardization should cover as much as possible —components, construction procedures, maintenance systems, operations procedures, plant upgrading, etc.— if we are to achieve the full benefits expected.

The situation in Europe is more unfavorable than in the USA because of a diversity in regulatory requirements and industrial codes for each country, with their corresponding organisms and independent licensing systems.

The creation last year in Europe of the company Nuclear Power International (NPI) with a 50 % participation between SIEMENS-KWU and FRAMATOME is a first step in the right direction since it will undoubtedly help to pave the way to unification of criteria and international collaboration. Nevertheless, given the magnitude of the task, this or other similar initiatives may not suffice. In my opinion, what is needed is the determined support of the main electrical European companies in an international collaboration plan. Thought could also be given to furthering the participation of professionals through their corresponding associations, like the nuclear societies. Ultimately, it would be recommendable to strengthen the role of such international organizations as the IAEA and the CE who can provide formal channels for the unification of criteria and requirements.

Finally, the problem of public opinion. In Spain, the lack of a clearly defined nuclear policy since 1983 to the present time has sown confusion and contributed to the development of unfavorable public opinion. Political commitment and participation in well-founded programs for international cooperation would contribute favorably in the medium and long terms to achieving excellence in overall performance and, by doing so, regain public confidence. The resolution of our problems therefore not only depends on the adoption of suitable criteria, but also on the capability of efficiently fulfilling them. In other words, what it boils down to once more is good management.