OVERVIEW OF NUCLEAR ENERGY IN SPAIN.THE ROLE OF A/Es

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More than 35 years have past since Spain undertook the initial tasks that would lead to the introduction of nuclear energy as a new source of electric power generation. In 1968, José Cabrera the first in a long series of planned nuclear power plants was connected to the grid.

Contracting of the different power plants in the nuclear programme was based on free international competition, but with a firm policy to support the growing participation of local industry. It was in this context that Spanish engineering firms started out on the learning curve in the nuclear sector, participating as subcontractors to the foreign "turnkey" suppliers for the first three units to be built.

In 1971, in the footsteps of the American vanguards, contracting "by components" replaced the turnkey system in Spain. This change boosted the industry's aim for overall participation; total investments of 45% in the previous phase reached 75% in the second generation of power plants and 85% in the third. This gave way to fast development of the nuclear industry in Spain. The A/Es played a significant role, supporting the electric utilities that owned and managed the new nuclear projects.

EMPRESARIOS AGRUPADOS

It was against this background that, in 1971, Empresarios Agrupados commenced its activities in Spain as an engineering firm created for the development of the nuclear programme. Additionally, the firm's corporate purpose also included engineering and design for fossil-fired power plants.

Empresarios Agrupados came into being as the result of a long-term collaboration agreement between three Spanish engineering firms, EPTISA, GHESA and TRSA. At the end of 1995, EPTISA's participation was acquired by TRPI (a subsidiary of TRSA), IBERINCO (a subsidiary of IBERDROLA), UFISA (a subsidiary of Unión Fenosa), and NU I+D (a subsidiary of CSE).

Empresarios Agrupados' expertise was acquired through a collaboration agreement with the American architect-engineering company Gibbs & Hill Inc. The technological transfer process that began in 1971 was completed by the end of 1979. It was then decided that Empresarios Agrupados should undertake the completion of all the engineering and design for the nuclear projects under way: two PWR units in Almaraz, one BWR in Cofrentes and two BWRs in Valdecaballeros.

Empresarios Agrupados has been the main or sole engineering firm for six nuclear units of approximately 1,000 MW: two Westinghouse PWRs (Almaraz), three General Electric BWRs (Cofrentes and Valdecaballeros) and one Kraftwerk Union PWR (Trillo). In three of these units (Almaraz and Trillo), the engineering scope was completed with project management, purchasing and expediting, construction supervision, and testing and start-up.

In 1983, Empresarios Agrupados had 2300 people under contract —more than 80% dedicated to the nuclear field— and this number had to increase to a maximum of 2600 in 1985 in order to complete the work contracted. That same year, one project alone —Trillo Nuclear Power Plant, a KWU 1040 MWe PWR— required 1400 persons from Empresarios Agrupados to work on it at its peak, 700 at head office in Madrid and 700 at site. As the Trillo project came to an end and with no further new nuclear projects in sight, we were obliged to reduce human resources and diversify into new fields. Subsequently staff levels fell to around 1000 persons, a figure which has been maintained to the present.

PRESENT SITUATION

Due to a series of circumstances known to all, the construction of a nuclear power plant has often turned into an extremely complex, uncertain task, with effects both on investment costs and on execution schedules. This, together with increasing public objection to nuclear energy, has caused the paralysation of programmes in many countries.

On the other hand, today there is a growing world-wide tendency towards deregulation and free competition in the power generation market. In this regard, it seems unthinkable that the historical financial risks recorded for nuclear power plant construction in many western countries could now be assumed by any utility within a free-market environment.

However, the fossil fuels we use today are unsustainable — above all, oil and gas — and there is a growing need for energy resources for the economic development of many countries; all this will make nuclear energy necessary as the only alternative that can meet the majority of energy needs in the medium to long term.

In addition to the foregoing, at the present time there are more than 350 000 MWe nuclear in operation throughout the world, and new plants are being built — albeit it at a moderate pace.

These circumstances allow the existence of and make it advisable to maintain a nuclear industry capable of efficiently supporting the operation of the park, to improve performance and safety aspects, to prolong useful plant life, and to gain experience that can be reflected in the design of future generations of nuclear power plants which, without doubt, are going to be needed in the future.

In this context, support to Spanish plants in operation, collaboration on international programmes for the development of the next generation of nuclear power plants and participation in extremely diverse work in the international arena, have enabled Empresarios Agrupados to maintain an important level of activity in the nuclear sector, in which 60% of its staff still work.

THE STANDARD PLANT

Based on all the experience of the nuclear industry and also on technological development in different fields, it may be said that it is both possible and necessary to design and construct plants that are progressively safer, more reliable and above all more economical. With the new nuclear power plants, it should be an achievable goal to match the cost of the KWh being obtained nowadays with the most competitive power generation facilities, without waiting for another energy crisis —perhaps more severe than previous ones— to come and "solve" this problem for us.

The industry's experience shows that the only way to attain nuclear power plants that are increasingly safer, more reliable and more economical is through standardisation. This is no mean feat, and certainly requires a great effort in engineering and management, and open international collaboration — beginning with the acceptance of uniform safety criteria.

The standard plant will be a safer facility. It will benefit from proven basic and detail engineering, in full compliance with the spirit of applicable safety criteria. It will have been built to a higher quality on the experience of other units in the series, and it will be operated following well-tested procedures.

The standard plant will be a more reliable facility. This reliability will be derived from a mature design, from the improved quality of its components and their installation, and from optimised maintenance based on experience with the series.

The standard plant will finally be a more economical facility. As a matter of fact, standardisation will help to rationalise general project management; to distribute through the series a significant part of the growing cost of engineering; to optimise the construction process, making it cheaper and shortening completion periods; and to reduce operating and maintenance costs.

Success with standardisation has already been experienced on a national level, as in the case of France, showing that this objective is possible. Effort is also now being made along these lines in the USA and Europe. Nevertheless, a firm political decision has to be made before these initiatives can materialise in the West. On the other hand, right now there is a greater possibility that standardisation of future nuclear power plants will become a reality in the Far East, mainly in Japan and China.

RESTRUCTURING OF THE NUCLEAR INDUSTRY

The volume of architect-engineering services — including construction management— necessary for a nuclear power plant has reached incredible figures in the past: 10 million man-hours and 1400 people at peak in more recent projects. Absorbing the associated cost of around 500 million dollars in one single project —approximately the total investment in a hypothetical 1200 MW combined-cycle gas plant— is unthinkable. However, it is not likely that the development of a nuclear power plant these days would require less effort in engineering and management if we are talking about the first of its kind. On the contrary, technological development goes along the lines of more analyses, more calculations, more simulations, etc. The problem can only be solved by widespread sharing of a significant part of this effort in plants built in series.

The aim of standardisation is the construction of a long series of nuclear power plants with identical basic and detail engineering, construction procedures, equipment and components. The process of ideal standardisation would also extend to plant operation and maintenance procedures and systems. Each plant in a standard series would benefit from experience in the construction of the previous ones and from the operation and maintenance of them all.

Each standard series would give rise to successive series which could incorporate state-of-the-art technologies and gain from lessons learned in construction and operation, thus permitting periodic updating of the standard design and preventing technological obsolescence. Some of the improvements of the new standard designs would also be made in operating plants.

The implementation of this standard plant concept will undoubtedly require restructuring of the nuclear industry. A return to the turnkey formula is foreseeable, placing management in the hands of very professional companies or consortia with wide experience. What's more, turnkey bidders may also have to include maintenance and operating support services with fixed prices and availability guarantees, all covering long periods of time. The electric utilities would participate to a far lesser extent in these projects but, as compensation, a significant part of the risk they once assumed will be transferred to the industry — not only during the construction phase, but also during operation.

ENGINEERING AND STANDARDISATION

As I mentioned, the volume of engineering associated with future nuclear power plants, far from decreasing, will increase, but it will be spread over series. The state-of-the-art of these complex facilities will require industry to dominate more technological fields in greater depth. This is also true of the foreseeable outsourcing of services to which the electric utilities will look more and more as reliable, economical offers become more commonplace.

By its very nature, the standard plant requires careful engineering and design. The required extent of reliability must be included in the design of systems, equipment and components. The concept of plant availability must be developed throughout the design using the latest knowledge in this area. Optimum equipment and component maintainability has to be formally established from the outset. And, finally, the best response has to be given to each and every safety requirement.

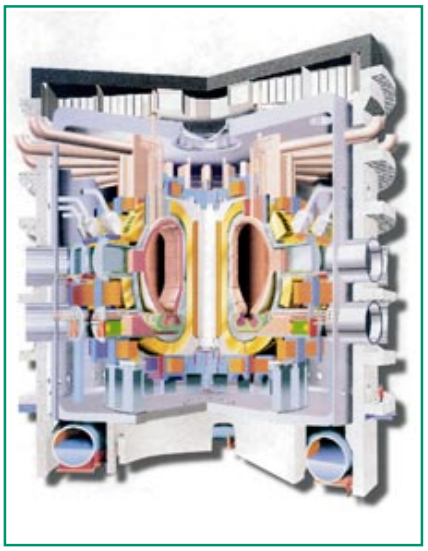
In relation with the criteria I have just referred to, which represent the introduction of the RAMS concept —reliability, availability, maintainability and safety— in the initial design, we must work towards perfecting the techniques of simulation and systems analysis, probabilistic risk analysis, complete life-cycle analysis, etc, as tools for common use right from the conceptual phase of the plant. This process can improve both with the appearance of advanced calculation and simulation tools, and also on the basis of information derived from the operation of standard plant series.

Furthermore, within the concept of standardisation there is ample room for engineering in optimising the construction process, from which important benefits can be reaped at less cost, better quality and shorter execution periods.

The very concept of a standard plant demands the incorporation of advanced integrated information systems which facilitate document configuration management. Inclusion of these systems should begin during the preliminary engineering phases, integrating all data of interest for the standard design, for the part of the design specific to each plant, and for the complete life cycle of the series and of the plant. Tools for this objective already exist and they are sure to be perfected in the future.

There is another wide field of potential engineering activity in the most ambitious objective for future standard nuclear plants, which we could call Integrated Logistic Support (ILS). This concept —in full development in complex Defence systems— covers design areas like RAMS, life-cycle analysis, logistic support management, technical documentation and publications, residual life assessment, operating experiences, maintenance plans, training plans, etc — all conceived with an integrated, uniform criterion.

Finally, there are two technological areas of perfection for future nuclear power plants that are of special interest: the human-machine interface and monitoring of material behaviour. In both cases, the development of electronics allows the use of an ever increasing range of precision supervisory tools that offer complex information on plant status and its expected evolution, which can be of assistance in its



operation and maintenance. The useful life of nuclear plants, which could extend to 60 years, makes this area of development of primary interest.

So as we can see, the possibilities and needs for engineering work are many in the development and implementation of standard advanced plants. Therefore, standardisation evidently does not mean the end of the numerous engineering needs in the nuclear field.

THE ROLE OF THE A/E IN STANDARD NUCLEAR POWER PLANTS

I have just given the reasons for which future generations of standard nuclear power plants are going to require engineering services of greater volume and quality than the present ones.

Assuming it is as I have described, the question is, in the new industrial setup in the sector — will there be a role for A/Es? My personal opinion is yes, there will be, but only for companies who know how to find their niche. I believe that operational flexibility, large project management skills, non-identification with a specific nuclear reactor type, working experience in different parts of the world, etc, will help them to make worthwhile complementary contributions. To support the feasibility of this kind of collaboration in the future nuclear field, I would like to quote three examples:

THE ADVANCED REACTOR PROGRAMME: Towards the end of the '80s, the American electricity industry —through EPRI, its DOE and nuclear industry— set in motion a development programme for the new generation of nuclear reactors, both evolutionary and passive, open to international collaboration. In 1992, the Spanish electric utilities decided to participate through an agreement with EPRI. At the same time, our Ministry of Industry promoted the participation of Spanish industry in the programmes led by GE and W.

This gave rise to the significant participation of a joint venture formed by INITEC and Empresarios Agrupados —as architect-engineer— in the development of GE's SBWR and ABWR, and in W's AP-600. EA also participates under its own financing in the development of GE's new ESBWR passive reactor, adapted to the European market. The success of this collaboration has since given way to the joint venture's participation in the two ABWR units that GE is supplying for the Lungmen nuclear plant in Taiwan.

TACIS AND PHARE PROGRAMMES FOR EAST EUROPE: It is well known that the EU has an ambitious programme under way to help improve the safety of nuclear power plants in East European countries. Empresarios Agrupados has been participating in the programme since it began and has won contracts for more than 40 projects to date. EA develops part of the work through ENAC, the European Nuclear Assistance Consortium, in which we have a 14% participation. SIEMENS, FRAMATOME, ANSALDO, NNC and ... EDF, are also members of ENAC. Much of the work is carried out jointly among the members and it is undoubtedly a fine example of fruitful collaboration among large industrial companies of the nuclear sector, architect-engineering organisations and electric utilities.

ITER NUCLEAR FUSION PROJECT: This is a project encompassing wide international collaboration — Europe, USA, Japan and Russia — which aims to demonstrate the feasibility of nuclear fusion by magnetic confinement as a means of generation of electricity.

Empresarios Agrupados and Sener, through IBERTEF, have a 9% participation in EFET, a European Economic Interest Grouping, which embraces such companies as SIEMENS, FRAMATOME, FIAT, NNC ... As in the case of ENAC, the European part of ITER's engineering work, which is EFET's responsibility, is developed among its members. The distribution of work is decided upon mutually, based on the characteristics and experience of the member companies. It is a project which —if completed— will be allocated a budget of 10 billion dollars for the construction phase.

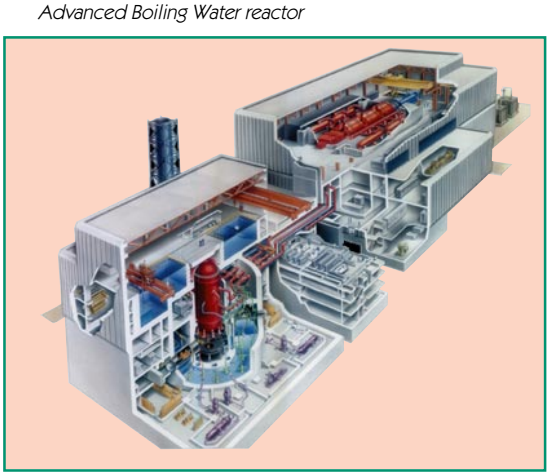
CONCLUSION

Future nuclear power plants have to be more reliable, safer, and above all more economical than those of today. A more advanced design, better quality equipment and components, an optimised construction process and perfected operation will all contribute to this end. Technological progress in organisation and management, in engineering tools, in electronics, in materials, all incorporated in a process of gradual perfection derived from the construction in series of standard nuclear power plants will all help to achieve these objectives.

The whole nuclear industry will have to be restructured to respond to this market and social challenge. The new scheme offers architect-engineering companies that know how to adapt to market requirements a clear role as part of the organisations which will foreseeably offer turnkey power plants.

The Spanish advanced power plant programme served to help its industry and, above all, the architect-engineering companies, to start collaborating actively in this new process. Our participation in the advanced project of Lungmen is the result of this policy. It is essential to continue with the effort being made in Spain to participate in the development of future standard advanced plants, within the context of projects with wide international collaboration.

Advanced Boiling Water reactor



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He authored the book titled "Trabajar en la Industria Nuclear", published by the Fundación Universidad Empresa.