THE LOSS OF KNOWLEDGE IN NUCLEAR SAFETY AND RADIATION PROTECTION DURING THE SPANISH NUCLEAR MORATORIUM

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Abstract. Nuclear power development started very early in Spain. By 1972 the first generation of power plants was already in operation; basic legislation was enacted, research and development encouraged, including fuel cycle, and an Institute for Nuclear Studies started soon to develop training and education. By 1982 eight plants were in operation and seven under different stages of construction. In 1983 the Government decided to cancel the construction of five units, two of them almost finished, confirmed a moratorium on the construction of new plants and declared the fuel cycle open. These actions put a halt in the nuclear development of the country, reduced the research efforts and nuclear education and training came down to a minimum. The country has now eight plants in operation and industrial and learning activities are mainly limited to service such operations. Site selection and characterization, plant design and construction and plant testing and commissioning have not been practiced in the last 20-30 years; the knowledge and experience then gained has been recorded, using the methods of the time, but the tacit knowledge is practically lost. Any new development of nuclear energy in the country will face the shortage of knowledge and experience in the said activities. All affected stakeholders, including the regulatory organization, need to take steps to remedy the situation. The loss of knowledge on radiation protection and nuclear safety has been given a special attention.

1. Introduction

Nuclear technology is intensive in intellect; it is based on one of the newest branches of science: nuclear physics, itself demanding a high level of intellectual capability; moreover, the risks associated to ionizing radiation have to be minimized based on two new branches of science and technology: nuclear safety and radiation protection. The first demanding new knowledge in criticality physics, radiation effects on materials, thermal hydraulics and severe accident phenomenology, among others. The second requiring also new knowledge on radiation physics, radiation biology and environmental physics. This knowledge and experience has been acquired and accumulated along the time through the work of many specialists and it constitutes an asset which is necessary for the safe and economic exploitation of present nuclear facilities, mainly nuclear power plants, and for any new development of nuclear energy.

Most OECD countries initiated very early the development of nuclear energy for peaceful purposes and started to gather the knowledge and experience necessary to build up complete fleets of nuclear power stations and their related fuel cycle installations. Spain was one of such countries. Nevertheless, in the eighties the antinuclear movement led some governments to create moratoria to the construction of new power stations, to limit their operating times and to cancel the construction and operation of some existing plants. In some countries the industry itself lost interest in the construction of new units; some already going projects were stopped and fuel cycles were declared open. In such countries, there was a stop in the acquisition of new knowledge in the siting, design, construction and commissioning of new plants and fuel cycle installations. In 1983 the Spanish government introduced a moratorium on the construction of new nuclear power plants and cancelled the already well advanced construction of five nuclear power plants.

The management of nuclear knowledge has a matrix structure in the sense that it includes different stakeholders and subject matters. Main stakeholders include: designers, suppliers, constructors, engineering companies, electrical utilities, service companies, regulatory organizations and nuclear research centres. The subjects are wide and they include new as well as old sciences and technologies, in the later case affected by the more stringent requirements on quality and perfection demanded by the nuclear applications. In this paper, it is analyzed the effects of the Spanish nuclear moratorium on the acquisition and preservation of knowledge in nuclear safety and radiation protection on the early phases of the life of a nuclear power plant and how could it be recuperated in the case of a probable renewal of nuclear power.

2. The Spanish nuclear development

The Spanish nuclear development started very soon. In 1951 the Nuclear Energy Board was created as a research and development organization to acquire and promote knowledge on the use of nuclear in science and in industry. Those advances needed, in parallel, the creation of basic regulations and institutions, the performance of research and development and the establishment of an educational and training programme. These activities are considered briefly.

2.1. *The legislative background*

In the early days a major preoccupation rested on the use of radioisotopes in medicine, industry and research and how to protect users and the general public against the effects of ionizing radiation. In fact, the first piece of regulation was a 1959 Presidential Order [1] on radiation protection patterned after the first EURATOM document on the matter. In 1964 the *Nuclear Energy Law* [2] was promulgated and subsequently developed into detail prescriptions. Chapter VI of the law defined the basic nuclear safety and radiation protection principles to be followed in establishing detail regulations on this matter. Three basic documents developed the nuclear safety and radiological protection principles in the law. The first one was issued in 1967 on *Third Party Liability* [3], the second in 1972 on *Nuclear and Radioactive Installations* [4] and the third in 1987 on *Radiation Protection* [5]. All these documents have been amended several times to cope with advances in nuclear safety, nuclear technology and radiation protection. The Nuclear Energy Board kept most of the responsibilities derived from those legal documents. In the late seventies, following the practice in other countries, it was recognized that promotion and control should not be invested into a single organization. In 1982 a new law was promulgated creating the *Nuclear Safety Council* [6] as a separate independent regulatory organization.

The Decree on *Third Party Liability* was based on the Paris and Vienna Conventions and it has been amended to cope with their developments. The Decree on *Nuclear and Radioactive Installations* establishes the basic regulatory procedures for licensing and regulation. For detail regulations regarding siting, construction, operation and dismantling it is established that national regulations should be complied with first, to be followed by recommendations from International Institutions, mainly the IAEA, from which Spain is a Member country. In the third place, regulatory documents from the country of origin of the project would be accepted. In practice, mainly in the early days, those last documents were the most frequently used. The Decree on *Radiation Protection* and its amendments are basically based in the successive Euratom Directives that the country has to follow as a consequence of been a party to EURATOM. The moratorium has restricted the development of regulations covering the early phases in the life of the nuclear power plant.

2.2. The scientific and technical development

The implementation of nuclear power started in Spain in the sixties. In 1960, the Nuclear Energy Board started the development of nuclear prototype called DON, fuelled with natural uranium, moderated by heavy water and cooled by an organic fluid. A critical assembly was built for reactor physics and several test rigs, but the project was abandoned after much effort and knowledge gathering. Apart from that, the Nuclear Energy Board imported a 3 Mwt swimming pool reactor, built another 1 Mwt reactor of the same type, two Argonaut types of reactors for the Industrial Engineering Schools in Barcelona and Bilbao and a fast neutron source reactor. A great deal of research in reactor physics and nuclear technology was accomplished.

In a parallel way, the electrical utilities started to considerer the use of nuclear power for electricity production, the demand of which was then growing in the country at more than 8 % per year. In 1972, the first generation of nuclear power plants was already in operation. The first included a Westinghouse, one loop, 160 Mwe, PWR which has operated for 38 years. The second was a General Electric, direct cycle, 460 Mwe BWR/3 in operation. The third was a French gas cooled, graphite moderated and natural uranium, 500 Mwe reactor, now dismantled. The early introduction of three different technologies gave the utilities the possibility of comparing their performance for a later decision; it also enlarged the knowledge and experience in the regulatory organization.

Table I. The Spanish nuclear power plants indicating the year they received the site, construction and operation licences

NAME	**TYPE**	**POWER** (Mwe)	**SITE** (year)	**CONS.** (year)	**OPER.** (year)	**STATUS**
1st Generation						
José Cabrera	W-PWR-1L	160	1963	1964	1968	Decomm.
Garoña	GE-BWR/4	460	1963	1966	1971	Operating
Vandellós I	F-GCR	500	1967	1968	1972	Dismantled
2nd Generation						
Almaraz I	W-PWR-3 L	930	1971	1973	1982	Operating
Almaraz II	W-PWR-3 L	930	1971	1973	1984	Operating
Lemóniz I	W-PWR-3 L	930	1972	1974	-	Cancelled
Lemóniz II	W-PWR-3 L	930	1972	1974	-	Cancelled
Ascó I	W-PWR-3 L	930	1972	1974	1985	Operating
Ascó II	W-PWR-3 L	930	1972	1975	1986	Operating
Cofrentes	GE-BWR/6	975	1972	1975	1985	Operating
3rd Generation						
Valdecaballeros I	GE-BWR/6	975	1975	1979	-	Cancelled
Valdecaballeros II	GE-BWR/6	975	1975	1979	-	Cancelled
Vandellós II	W-PWR-3 L	930	1976	1981	1988	Operating
Trillo I	KWU-PWR-3L	1030	1975	1971	1988	Operating
Trillo II	KWU-PWR-3L	1030	1975	1980	-	Cancelled

A second generation of nuclear power plants started immediately after, it included six Westinghouse PWR-3 loop, 900 Mwe plants, all of then of the same vintage, and a General Electric BWR/6 1000 Mwe plant. Four of the six PWRs and the BWR entered operation in the early eighties and keep running successfully. A third generation of plants was soon envisaged including an additional Westinghouse PWR-3 loop plant of improved design, two General Electric BWR/6 and two KWU-PWR-3 loop plants with KONVOI features. From this set only the Westinghouse PWR and one KWU PWR were built and are now in operation, the construction license for the others was cancelled by the moratorium. The names of these plants and their major features are included in table 1.

2.3. Education and training

Chapter III of the Nuclear Energy law is dedicated to research and education. The law created an *Institute for Nuclear Studies*. It also provided the basic principles for the creation of Chairs in Universities and high level educational centres and the granting of scholarships in national and international educational institutions. The Institute for Nuclear Studies maintained specialized and long term basic courses in nuclear science and technology, frequently inviting foreign professors. Radiation protection and nuclear safety were frequently objects of special consideration and always a significant part of the basic courses. IAEA regional and interregional courses were frequently conducted in the Institute premises. Most of the Spanish nuclear scientists and engineers acquired their first knowledge through such activities. When the demand for specialist grew, some Polytechnic Universities started to offer courses on reactor physics, nuclear technology, nuclear safety and radiation protection.

On their part, the electrical utilities sent at the beginning their future reactor operators to appropriate institutions in the country of origin of the corresponding plant. For the second generation of plants, i.e., in the early seventies, the utilities decided to train their personnel in the country though Tecnatom, the first nuclear service company created in the country in 1957. Full scale simulators were built and trainers were prepared to accomplish that mission. There was a great deal of optimism at the time, the participation of the domestic industry was encouraged and growing, national participation in the design and construction are evaluated in table II. At its peak, more than 50 000 workers, with some three thousand university graduates, were engaged in nuclear activities.

Table II. Participation of the national industry in the design and construction of the Spanish nuclear power plants, (%)

	First Generation (3 NPPs) (1964-1972)	**Second Generation (7 NPPs) (1972-1982)**	**Third Generation (2 NPPs) (1977-1987)**
Total	**42-44**	**65-70**	**80-86**
Equipment	24-25	45-55	70-78
NSSS		30-35	70-75
Turbine-Generator		30-40	55-60
Mechanical		70-80	85-90
Electric and Instrumentation		75-85	>90
Engineering	59-70	75-80	100
Assembly	80-85	100	100
Civil work	65-75	100	100

There was research and development, as well as knowledge gathering, in the national research laboratories and the universities. The industry provided heavy and all type of components, fuel fabrication was also national, the whole fuel cycle was given attention, architect-engineering and servicing companies were also created. But all this enthusiasm started to decline when the Government decided in 1983 to cancel the construction of five units, to establish a moratorium to the construction a new units and to declare that the fuel cycle should be open.

3. **The moratorium**

The Spanish moratorium was mainly based on political reasons, although economical constrains were declared. The electoral programme of the Socialist party for the 1982 legislature included an installed power limit of 7, 5 Gwe from nuclear origin. At that time there were seven plant in operation and seven more under different stages of construction with a total electrical capacity above 12 Gwe; therefore the construction of at least five units should be halted. The Socialist party won the elections and the promise had to be honoured. Studies were performed to determine which plant should be stopped and the reasons for that. Nuclear safety studies were performed to determine if there were safety reasons or large differences in the safety levels of the different ongoing projects, it was found that all plants had demonstrated their safety levels to be similar among themselves and comparable with that of similar plants in the country of origin. Economical studies were also performed and the conclusion was reached that two Westinghouse PWR-3 loop plants, practically finished; two General Electric BWR/6 units, more than 50 % built, and one of the two KWU PWR-3 loop plants, just starting construction, should be cancelled.

The Decree creating the moratorium was approved by Congress and put into force in 1983; it also included a prohibition to build new nuclear power units and declared the fuel cycle open. Up to that time, the Spanish spent fuel elements were sent to the United Kingdom and France for reprocessing, the banning of such activity created the problem of increasing the capacity of the spent fuel pools. The Decree was later reinforced by a law [7]. In 1986 the Nuclear Energy Board, entirely devoted to nuclear, was transformed into a research centre for energy, the environment and technology, CIEMAT; the research reactors, hot cells and other nuclear research facilities were closed down and the research on nuclear fission considerably reduced. The old Institute for Nuclear Studies was transformed into a new *Institute for Energy Studies* and nuclear related courses were considerably reduced.

The moratorium started the decline of nuclear energy in the country. The nuclear utilities were disappointed and they will not start any new nuclear plant without previous government assurance. Nuclear activities were reduced to the operation of nine power plants, now eight after closing down the José Cabrera plant in 2006. Architect-engineers and service companies started to look at other fields and considerably reduced their nuclear personnel. The national constructor of heavy equipment, ENSA, diversified its production and has been manufacturing some heavy components for export, mainly steam generators and pressure vessel heads. The fuel manufacturing company, ENUSA, has limited its production and it keeps a small share of the international fuel market. Only TECNATOM is providing regular training and inspection services for the national operating plants and also keeps shares in the international market for such services. The interest for nuclear education declined considerably. Some nuclear research is kept, but mostly reduced to the EURATOM research programmes with emphasis in operation, nuclear safety and new reactors.

As nuclear power should not be completely discarded in the future, it is of interest to evaluate the knowledge and experience lost in nuclear safety and radiation protection, in both the industry and the regulatory body, to see whether or not it could be recuperated and to establish conditions for a potential nuclear renewal. For doing that, it will be of interest to analyze the cycle of life of a nuclear power plant to determine the nature of the knowledge and experience which has not been put into practice for a long time and how could it be recuperated, if needed.

4. The cycle of life of a nuclear power plant

The life of a nuclear power plant includes six main phases: site selection and characterization, design and construction, commissioning, operation, decommissioning, and long term spent fuel management, comprising about 100 years and at least three generations of workers. In table III the phases are defined and the nature of the knowledge required is explained.

Each one of these phases requires specific knowledge and experience, which has to be managed along the life of the nuclear energy deployment in any country. When such a deployment is interrupted and later on resumed, as it may be the case in Spain, the knowledge and experience gained during the first phases could only be effectively transferred to the new development if a proper knowledge management was implemented, which was not normally the case in the early days. The knowledge gained is certainly in the files and archives for everybody to read, but it can only be read effectively by those who have participated in creating the knowledge. The experience is lost with the people. Nevertheless, methods and modes are being considered to re-acquire such knowledge and put it into practice in the event of a new nuclear development. In many cases a new start will be necessary for both the regulatory organization and the interested utility

4.1.-Site selection and characterization

Site selection and characterization was very active in Spain during the 60´s and 70´s. Many applications for site permits were filed. Individual site studies were performed as well as studies on the potential nuclear capacity of some river basins and coastal regions. Knowledge and experience was accumulated and expanded on site specific meteorological and hydrological dispersion of contaminants, characterization of seismic faults, soil movements, extreme meteorologicl phenomena and many other earth related sciences and technologies. Specific requirements were also developed The Spanish regulations require a site permit. The last ones which have been granted in Spain date from 1975 and 1976, since that time no applications for sites have been filed in. In fact the present regulatory organization has not been yet confronted with a site application.

Very valuable knowledge was then acquired on this subject which was interrupted more than 30 years ago. Practically all participants in such studies are retired or missing, records are kept, but the tacit knowledge is practically lost. More recently, the analysis of external events for probabilistic safety studies has brought back some valuable experience related to sismicity, hydrology and extreme

Table III. The cycle of life of a nuclear power plant and knowledge needs

PHASE	**DURATION (years)**	**RADIOLOGICAL KNOWLEDGE**	**NUCLEAR SAFETY KNOWLEDGE**
1. Site selection and characterization	2-5	Radiological characterization. Definition of radiological site distances	Site input parameters. Extreme meteorological and geological phenomena. Man-made external inputs
2. Design and construction	5-8	Radiation shielding. Radioactive waste treatment. External releases. External and internal radiation monitoring. Radiation mitigation safeguards	Compliance with design criteria. Consideration of safety and security integration and synergies. Accident analysis evaluation. Inspection during fabrication and construction. Quality assurance and quality control.
3. Testing and commissioning	1-2	Verification of radiation protection related systems and components. Establishment of radiation dosimetry service. Establishment and testing of an internal and external radiological emergency plan	Verification and testing of safety related components, systems and structures. Nuclear testing from criticality to full power. Review and approval of test results. Licensing reactor operators.

4. Commercial operation	40-60	Establishment of an ALARA plan. Permits for radiation work. Monitoring releases. Workers dosimetry. Emergency drills.	Periodic testing and inspection of safety related components, systems and structures. Evaluation of malfunctions, incidents and accidents. Feed back of international operating experience
5. Decommissionin g	5-10	Radiological mapping. Dismantling plan. Radiactive waste management. Control of radiactive releases. Enhanced workers internal and external dosimetry	Verification of compliance with decommisssioning regulations. Accident analysis. Design of decommissioning systems and components. Transfer of knowledge from plant operators to decommissioning agents
6. Long term management of spent fuel	15-100	Radiological control of spent fuel and high level waste	Verification of compliance with regulations related to the long term storage of spent fuel and high level waste

meteorological conditions, but this new knowledge and experience only refers to existing sites and for a particular purpose. Finding new sites for a new substantial renewal of nuclear power in Spain will be a difficult job for the utilities. This activity will have to commence anew by redefining the detail radiation protection and nuclear safety requirements. The IAEA new set of standards will be a valuable asset for such purpose.

4.2. Design and Construction

Design and construction is a major endeavor. Spain is termed as a qualified importer, in the sense that the domestic industry participates in the design and construction of the imported plants and it is fully responsible for their operation. Only the first units were turn-key contracts. The participation of the Spanish industry, mainly in the balance of plant, structures and ancillary systems was intense. Quality assurance and quality control were the responsiblity of the plant owner. The regulatory organization also developed a great deal of experience in regulating design and construction and in verifying compliance with regulations, that were also growing. The last construction activities ended in 1986. Since that time, the activities of the regulatory body and national industry have been limited to implement modifications in the domestic plants. The new regulatory authority has yet to issue the first construction authorization. A new built will not profit much from the old experience.

In the Spanish regulations a construction permit is required. A series of documents have to be presented by the applicant, the *Preliminary Safety Analysis Report* being the most significant. The contents of such report is patterned to the US Regulatory Guide 1.70 [8]. The production of such report is the responsibility of the applicant, while the regulatory organization is responsible for its evaluation, which is conducted in accordance with the US Standard Review Plan. This requirement has created some problems with the German plant for which specific help from the German organizations was requested. The Preliminary Safety Analysis Report and its evaluation requires detail knowledge of nuclear and more conventional sciences and technologies, requiring a high degree of especialization.

To guaranty the safety of the proposed plant the Spanish regulatory authority at that time introduced the concept of *reference plant*, then recommended by the IAEA, in the sense that the proposal should have a licensed reference plant in the country of origin of the project. By comparing the design of the proposed and the reference plant the safety level of the proposed plant could be evaluated. To be valid, the site parameters have to be also comparable in both cases, which was not always possible. With time, the system evolved towards a more independt evaluation process making use of *reference systems* using multiple examples. This practice was considered practical and positive and a great deal of knowledge and experience was acquired. Nevertheless, the last construction permits were granted in 1979 and 1980. Again, the present regulatory authority has not so far been confronted with a construction permit application. Most of the people who participated in these exercises are already retired or missing and their tacit knowledge will be very difficult to recuperate.

The safety evaluation for the construction permit of a new plant will probably be more difficult than in the past. New designs include advanced safety features, contemplate prevention and mitigation systems for severe accidents and additional security requirements; moreover, safety and security must be integrated up to the maximum possible level. Spain acquired a great deal of experience on this particular matter before the moratorium. The regulatory organizations in countries already building or close to build new power plants are joining efforts to evaluate the new Generation III+ designs. The recently created *Design Evaluation Multinational Programme* [9] is a major and desirable step in the right direction, but only the countries participating will obtain a direct benefit from it. For the moment, Spain is not a member of such effort. As in the previous case, new detail regulations will have to be issued, with the probable help of the the IAEA safety standards.

During construction, inspections to guaranty quality assurance and quality control and to verify compliance with requirements are the most important activities of the regulatory organizations. Quality assurance and quality control are also practiced independently by the plant owner. During construction many interesting deviations are found requiring in depth analysis of their importance. This accumulated experience is generally recorded, but many interesting aspects of that belong to the tacit knowledge of the inspectors and evaluators. The last construction experiences ended in Spain in 1986 and many of the experts of this time are retired. Their explicit knowledge could be recuperated, but it will not be probably needed in some time.

4.3.-Testing and commissioning

Testing and commissioning is the phase when the interchange of knowledge between the supplier and the utility is more intense. The supervision of the regulatory authority is also considerably increased. The utility has been preparing during the four or five previous years the new operating personnel. A number of prenuclear and nuclear tests, up to the final acceptance test, are performed in collaboration between the experienced provider and the new operating team, many situations of interest are normally found requiring analysis, interpretations and corrections increasing the knowledge and experience of the participants. The last activity of this type took place in Spain in 1987, all this has been recorded, but a lot of practical experience is only in the memories of the participants. The original people who participated in the transfer of such knowledge and in gathering experience are now out of operation and replaced by new operating personel who have not seen that previous experience. The same applies to the regulatory body. Future deployment of nuclear energy may encounter difficulties in finding experts on that matter on both sides, the supplier and the receiver of the plant, as well as on the regulatory body. IAEA recommendations should be of help at this time.

4.4.-Operation, decomissioning and long term management of spent fuel

The last three phases of the cycle of life of a nuclear power plant are on-going activities. The regulatory body is requesting that methods should be established to increase, collect, maintain and use the operating experience in nuclear power plants, fuel cycle and waste disposal installations. The Spanish utilities and the national radioactive waste company are creating procedures to secure such knowledge and experience following the IAEA recommendations. The regulatory authority has recently issued an Instruction to maintain knowledge and experience on radiation protection matters. More Instructions may follow.

5.-Summary

Table IV summarizes the present situation regarding the knowledge and experience gained in Spain on radiation protection and nuclear safety matters related to the cycle of life of a nuclear power plant, and how this knowledge and experience has been affected by the 1983 moratorium

From Table IV it is deduced that the knowledge and experience gained on radiation protection and nuclear safety matters for the first three phases of the life of a nuclear power plant has not been increased neither practiced for the last 30-20 years. The implicit knowledge is certainly on the historical files, but the tacit knowledge is practically lost or difficult to recuperate. Likewise, from the table it is also deduced that three last phases are ongoing. In these activities the interests stays in establishing methodologies for knowledge management, as the strategic approah suggested by the IAEA for operating plant personel [10].

The lack of knowledge and experience for site selection and characterization should not be considered a major problem. The regulations and the methodology needs to be revised, but the basic sciences and technologies are well known. There are new more demanding requirements and safety guides requiring some expertize for an efficient development. The related stakeholders will mainly be the electrical utility interested in building a nuclear power plant, the architect-engineers with experts in earth sciences and the regulatory organization.

Design and construction of a new nuclear power plan will be a major activity when starting anew and it is recommended that the knowledge and experience previously gained is collected in the most efficient way. To that effect, the strategic recommendations given by the IAEA would be of value [11].There are new more stringent requirements and safety guides and new designs and construction practices, requiring an in-depth analysis from the regulatory side.

The construction time of a nuclear power plant has a paramount importance in the economics; this requires that there is a detail design, that significant problems will not be encountered during the construction producing delays. Likewise, regulatory requirements should be defined and solved before construction starts and no unnecessary delays in construction should be produced by the regulatory activities. The issue affects all nuclear related stakeholders: the electrical utility interested in building a nuclear power plant, the reactor and balance of plant suppliers, the architect-engineers, the service companies, the constructors, equipment manufacturers and the regulatory organization. The use of standard desings, already approved and certified by other more advanced regulatory organizations, mainly if they have participated in the ongoing design evaluation activities, will facilitate the regulatory process. In any case, the electrical utilities and the other stakholders will have to create in advance teams of experts with maximum experience and knowledge.

Table IV. Present situation and future prospects for management of knowledge in radiation protection and nuclear safety in the cycle od life in a nuclear power plant

PHASE	**PRESENT SITUATION**	**FUTURE PROSPECTS**
1. Site selection and characterization	The last site permit was granted in 1976. External events for probabilistic studies have been conducted since 1986 for existing sites	The tacit knowledge and experience gained has been practically lost. Any new site analysis and characterization will have to comenze anew
2. Design and construction	The last construction permit was granted in 1980. Plant modifications and capacity increases have been approved at different times	The tacit knowledge and experience gained in desing and construction has been practically lost. Any new built will be a major endever.
3. Testing and commissioning	The last plant was commissioned in 1987.	The tacit knowledge and experience in testing and commissioning has been practical lost. Any new built may find shortages in finding experts from the provider, the utility and the regulatory organization
4. Commercial operation	This is an ongoing successful activity	Procedures are been established to gather, maintain and use knowledge and experience gained

5. Decommissioning	This activity has already been practiced in Vandellós I and it is starting for the José Cabrera Plant	Procedures are been established to gather, maintain and future use of knowledge and experience gained
6. Long term management of spent fuel	This activity is ongoing. Capacity of spent fuel has been increased. On site dry storage for one plant is in operation. There are plans for a centralized dry storage facility.	Procedures and practices are beein established to gather, maintain and future use of knowledge and experience gained.

It has already been recognized the intense transfer of knowledge that takes place during commissioning between the reactor provider and the utility operating personel and the intense evaluation and inspection activities of the regulatory organization. A well done commissioning will avoid many later operational problems. The three stakeholders mentioned above will have to prepare themselves during the construction phase for the intense and short but highly demanding activity.

Knowledge and experience are significant assests in this phase. Therefore, everyting possible has to be done to recuperate the tacit and the explicit knowledge previously adquired.

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