
EMPRESARIOS AGRUPADOS

An Innovative
Organisation

December 2008



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Introduction

The architect-engineering organisation Empresarios Agrupados (EA) was founded in 1971 to support the launching of an ambitious nuclear power generation programme in Spain.

It was established as an operationally independent group to focus and channel the work and resources of three engineering companies interested in qualifying for designing and managing projects in the field of nuclear energy.

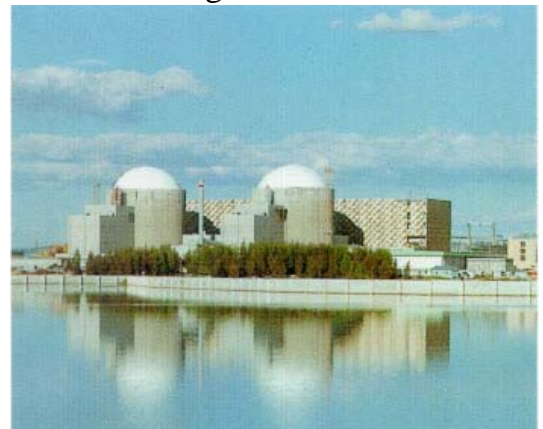
Today, four companies are partners in EA: Técnicas Reunidas, S.A., with a 43% stake in EA; GHESA Ingeniería y Tecnología, S.A. (34.4%); Iberdrola Ingeniería y Construcción, S.A.U. (11.3%); and SOCOIN Ingeniería y Construcción, S.L.U. (11.3%).

Overall management of EA's activities is entrusted to an economic interest grouping, Empresarios Agrupados AIE. For work on projects abroad, a public limited company was set up, Empresarios Agrupados Internacional, S.A. Diversification into aerospace technology led to the creation of the firm Ibérica del Espacio, S.A. (IberEspacio). EA presently employs some 1000 persons (65% of whom are university graduates) integrated within an organisation chart independent of the stakeholder companies.

Initial Qualification in the Field of Nuclear Power

EA's primary mission in the beginning was to gain initial qualification to work in the field of nuclear power generation, coinciding with the launch of the design and construction of the Almaraz Nuclear Power Plant in Spain. The process was organised with the long-term collaboration of a large American engineering and design concern, Gibbs & Hill, Inc (GHI), and consisted in dividing up the project work between EA and GHI, while at the same time enacting a technology transfer programme.

That formula was used to undertake the Almaraz, Cofrentes and Valdecaballeros NPP projects, in which GHI's scope decreased as EA's increased .



Almaraz NPP PWR W 2x980 MWe

By the end of the 10-year period, this technology qualification process had concluded and EA was given the complete scope of work still pending on Valdecaballeros NPP.

The Trillo Nuclear Power Plant project, started in 1975, was contracted entirely by EA as the architect-engineering organisation. This was the first time that a plant of German technology had been undertaken with SIEMENS-KWU (KWU) supplying only the main systems - Nuclear Steam Supply System, Turbine-Generator and Plant Control System - plus technical support in certain other areas. The complete plant design, the management of manufacturers and suppliers, and the overseeing of plant construction and tests were all within the scope of EA. It was also EA's responsibility to adapt KWU's German standard-based design criteria to the Spanish Nuclear Safety Council's American standard-based safety criteria. Empresarios Agrupados employed around 10 million man-hours in this project, with a peak workforce of 1400 employees, 65% of whom were university graduates.



Trillo NPP PWR-KWU 1050 MWe

The nuclear moratorium announced by the government in 1983 went into effect with the two Almaraz units and one Cofrentes unit already in commercial operation, while Valdecaballeros and Trillo were under construction. The moratorium stopped work on the Valdecaballeros plant even though the engineering was practically finished, but permitted the completion and commissioning of the Trillo plant, which took place in 1988.

It was around that time that the continuation of EA's medium and long term activities was put on the table for discussion. The decision took a positive turn based on a four-way plan of action: to support Spanish nuclear power plants in operation, open up to international markets, participate in R&D&I programmes and diversify operations.

Support to Spanish Nuclear Power Plants in Operation

Nuclear power plants require ongoing external technical support for resolving incidents, adapting to new safety criteria, updating the technology, monitoring material ageing and performing special operations such as uprating, useful life extension, and so forth.

Empresarios Agrupados has kept pace with new technologies to be able to render this support both to the plants it designed itself, as well as to the rest of the nuclear park in Spain.

Opening up to International Markets

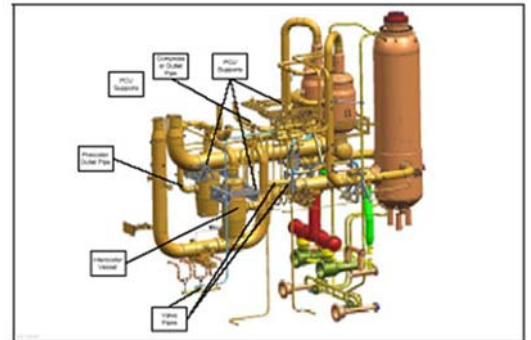
The second line of action was aimed at working in the nuclear field on the international stage, even though this activity had also been brought to a standstill in many other parts of the world. EA has been aggressive in developing its technological and commercial approach, and has been awarded contracts in this field in a number of foreign countries:

- Engineering work in the USA, including Comanche Peak 1 and 2 NPP, as well as other services in plants at LaSalle, Hope Creek, Haddam Neck and Calvert Cliffs, now in operation
- EA has carried out work on improving the safety of nuclear power plants in several countries that were former republics of the Soviet Union, financed by the European Union's TACIS and PHARE programmes and by the European Bank for Reconstruction and Development (EBRD)
- EA has been contracted as the utility's architect-engineers in the contractor selection contests for the construction of new nuclear power plants in Turkey (Akkuyu), Finland (Olkiluoto 3, currently in the construction phase), the Czech Republic, Lithuania and Switzerland
- EA has done engineering work for the Laguna Verde 1 & 2 nuclear power plants (Mexico) as well as for the nuclear plants Atucha 2 (Argentina), Angra 1 (Brazil), Angra 2 (Brazil), Alto Lazio (Italy), Trino Vercellese 1 & 2 (Italy) and Leibstadt (Switzerland). EA is currently participating in the Laguna Verde uprate studies
- As contractor to General Electric (GE), EA has carried out important engineering work over the past 7 years for the Lungmen NPP (Taiwan), which is currently in the commissioning phase



Olkiluoto 3 NPP PWR-Areva 1650 MWe

- EA has been working for more than 4 years in the design of the Pebble Bed Modular Reactor (PBMR), an advanced Generation IV (Gen-IV) nuclear power plant in the Republic of South Africa based on 165 MWe modules using high temperature gas technology. With EA's design, Equipos Nucleares, S.A. (ENSA) bid on and was awarded the contract to supply the Main Power System Pressure Boundary for the power plant. The reactor vessel itself is designed by ENSA

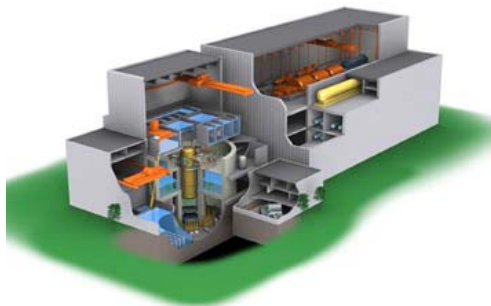


PBMR Nuclear Module – 165 MWe

Participation in R&D&I Programmes

EA has been actively participating in a number of R&D&I programmes in the field of nuclear power:

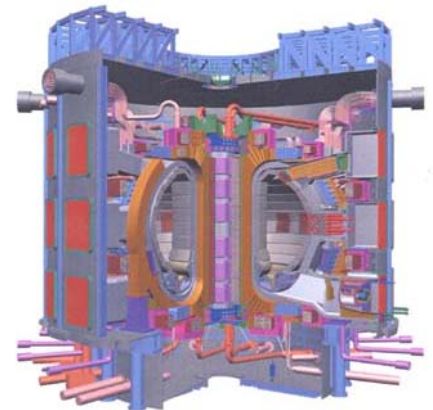
- EA participated in the development of the Generation III and III⁺ reactors, Westinghouse's APWR and AP1000 reactors, and GE's ABWR and SBWR within the American programme for Nuclear Regulatory Commission (NRC) certification of these types of power plants. EA's participation was financed with Spanish funds through UNESA (the Spanish Association of Electric Utilities)
- EA's participation in the development of the ABWR (Gen-III) led to important engineering contracts from GE for services to be executed in Taiwan. Further participation is envisaged in other projects using this type of reactor, probably in the USA
- For 15 years EA has been participating in the development of a new type of reactor for GE - the passive ESBWR (Gen-III+) – for deployment in the USA, the last 5 years at GE's initiative within the Nuclear Power 2010 Program of the United States Department of Energy (DOE). After financing its participation with its own funds in the early years, EA's work is now 50% financed by the DOE. EA is a key player on the technical team supporting NRC certification of this reactor, and will



ESBWR Standard Plant - GE 1600 MWe

participate in the construction of the future nuclear power plants

- EA plays an active role in a variety of European Union R&D programmes in the nuclear field. These include the gas-cooled reactor programmes, the Very High Temperature Reactor (RAPHAEL) and Gas Cooled Fast Reactor (GCFR), and liquid metal cooled reactors in the EISO FAR, ELSY, EUROTRANS and CDT projects, all of which involve the new technologies for the future Gen-IV systems being designed for power generation, transmutation and other applications. Although Spain as a nation is not participating in the Gen-IV International Programme, EURATOM is, and the president of EA is one of EURATOM's representatives on the Senior Industry Advisory Panel (SIAP), the Programme's leading consulting body
- EA is also participating in European Union R&D programmes on energy in general and specifically in the hydrogen generation programmes using thermo-chemical methods, such as the HYTECH, INNOHYP-CA and HCYCLES projects
- EA is part of the group of European companies that has been developing the ITER Project design over the past 14 years to demonstrate nuclear fusion technology in a large-scale experiment. EA is already active in the current material execution phase of ITER at the Cadarache site (France)



Fusion Reactor – ITER Project

All this hands-on experience has given EA far-reaching technological expertise while bringing EA international recognition as an experienced, innovative organisation in the field of nuclear power at a time of ebbing activity when other organisations have disappeared or changed their line of work.

Now that new policies are being explored for restarting nuclear programmes in various countries, EA's strategy has proven to be correct. In fact, there are important expectations of work for EA in this field in the near and medium terms at least in the USA, UK and France.

Diversification

The 1983 decision to halt the nuclear power plant construction programme in Spain led to the need to find areas for diversification using existing technological capabilities. Identified among such areas were thermal power plants, airports, the European space programme, technical support to defence, and various one-off, singular projects.

Thermal Power Plants

In the late 1970s, EA began to design and engineer coal-fired thermal power plant projects, of which 10 were built: 6 in Spain, 2 in Mexico, 1 in the Philippines and 1 in Chile. EA also completed various consulting jobs in the field of thermal power plant engineering.



Meirama Coal-fired Plant –550 MWe

In the early 2000s, new power generation focused primarily on using natural gas as fuel, by way of combined cycle power plants featuring high thermodynamic performance and a lessened impact on the environment. EA entered this field decisively, participating in 43 units with a combined power of 17,780 MW. Of these, 20, with a combined power of 8,776 MW, are currently under construction. More than 60% of this power is produced abroad.

Reactivation of the construction of fossil-fired power plants has increased the number of units in which EA participates to 21, with a combined power of 7,365 MW, between coal and oil.

As regards combined cycle power plants, EA has adopted the strategy of specialising in plants with main equipment supplied by GE, which now outsources all project engineering. To this end, EA has established an agreement with GE to develop co-financed standard reference plants using GE's FB and H cutting-edge technology gas turbines. As a result of this strategy, EA has been awarded numerous projects both in Spain and abroad.



**Lavrion Combined Cycle (Greece)
109 FA-GE 400 MWe**

European Space Programme



Ariane 5 Cryogenic Engine

In the late 1980s, EA diversified its activities into the aerospace field, making use of the returns criteria for Spain's contributions to the European Space Agency's (ESA) Programme.

The strategy materialised in the form of the company Ibérica del Espacio, S.A. (IberEspacio). IberEspacio's work initially centred on the Ariane 4 and Ariane 5 space launchers and included System Simulation, Advanced Structural Analysis, Reliability, Flight Data Analysis, etc.

The skills for carrying out these activities came mainly from our experience in the nuclear field. In the area of System Simulation, even before IberEspacio was created, EA had an agreement with ESA to develop a computer program, EcosimPro, specially designed to run dynamic simulations of life support systems in manned space vehicles. Later on, through co-financing with ESA, the computer program was equipped with new associated libraries and refocused towards dynamic simulation of more universal systems. EcosimPro is now ESA's space propulsion simulation program, using the ESPSS library currently being developed by EA. EA continues its ongoing development and marketing of EcosimPro to users around the globe, including NASA and its Canadian counterpart, CSA.

IberEspacio is currently developing a new line of business involving the design and supply of heat transfer systems based on capillary fluid circulation with phase change between the cold and hot source. These systems are initially aimed at cooling the electronic systems of space satellites, although future applications of great interest are envisaged. This activity was launched under a technology transfer agreement with the Russian company TAIS, and supported by the in-house R&D programmes co-financed under the Spanish Space Plan and ESA's technological development programmes. One worthwhile application already identified is their use for the silent, maintenance-free cooling of electronic systems in submarines.



Space Satellite

Technical Support to Defence

A number of different activities have been identified and developed in the area of providing technical support to Defence. Chief among them are Integrated Logistic Support Systems and Technical Publications Management with CALS standards and SGML philosophy.

The ALISIOS program is an advanced integrated logistic support tool developed by EA for the F-18 fighter aircraft flown by the Spanish Navy and Air Force. Additionally, EA has been systematically managing all F-18 technical documentation and the drawing up and updating of the aircraft Operating and Maintenance Manuals since these tasks were nationalised 12 years ago.



F-18 Fighter Plane

Aeronautics

IberEspacio has carried out activities in the aeronautics sector in relation to the Technical Publications for different engines, and the design and calculation of fuselage structures, particularly for the belly fairing of the different models of the Airbus family. In the area of R&D&I, components are being developed for two-phase heat transfer components that will be able to solve the problem of de-icing plane wings and will generally optimise the thermal performance of the engines.



Using its expertise in dynamic simulation, EA has also taken part in the VIVACE project under the European Union's Sixth Framework Programme (FP6). For this project, EA has developed the PROOSIS computer program, which will serve as a common tool for all European industries involved in aircraft engines. The goal of PROOSIS is to set a standard that will make it easier for the industry to work together in designing new engines. Indeed, PROOSIS has already been acquired by the Snecma Moteurs group. Development of this program will continue under FP7.

Airports

In the mid 1990s, EA detected a business opportunity in the field of airports, coinciding with a large Spanish Airports Authority (AENA) plan to modernise airports in Spain.

Since 1998, EA has provided technical services to AENA in collaboration with Técnicas Reunidas and GHESA, first in the Terminal 4 project for Madrid Barajas Airport and then in other projects at airports in Malaga, Alicante, Gran Canary and Santiago de Compostela.



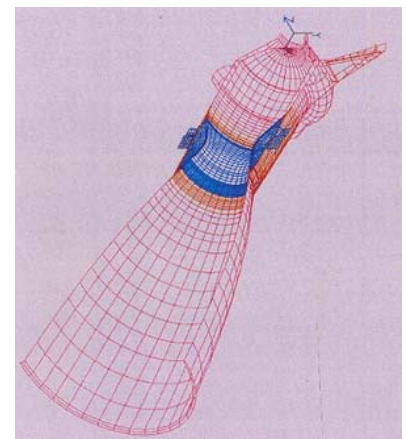
Barajas Airport – T4

For the Barajas Plan, EA took a key role in the new T4 terminal, providing Technical Consulting Assistance to AENA's Programme Management on the construction of the new terminal. EA has also participated in other specialised areas such as the definition and implementation of the Information System, management of the Automated Baggage Handling System project, with its 92 km of conveyor belts, management of the Security System project, and overseeing the Energy System project.

Singular Projects

EA has maintained a strategy of carrying out singular projects that require special skills and capacities. Offered below are 6 undertakings that are typical of these projects.

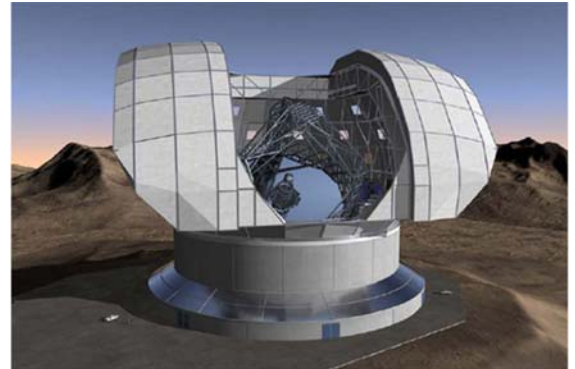
- Dynamic structural study of the in-flight behaviour of the neck of the Ariane 4 VIKING engine. The enormous number of nonlinearities in the behaviour of compound materials made it necessary to fine-tune a highly sophisticated complex analysis process. The results were used to analyse the causes of the problems detected in the equipment and to propose solutions to improve its structural behaviour
- Reliability study of the NASA space shuttle. A probabilistic safety analysis was carried out of the space shuttle main engine (SSME) and of the reusable solid rocket motor (RSRM)
- Design of the dome and the mechanics of the *Great Canary Telescope* (GCT). It is one of the largest telescopes in the world (its primary mirror is 10.4 m in diameter)



Ariane 4 Viking Engine

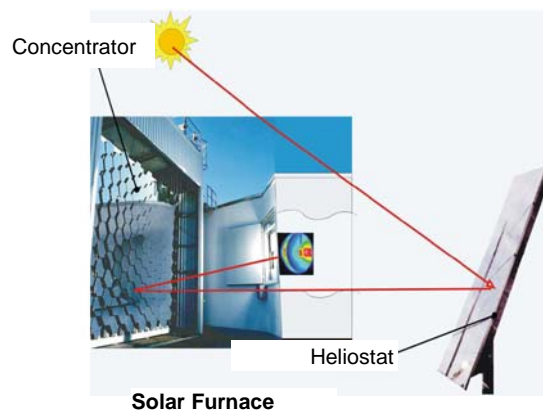
and currently the most modern. In collaboration with IberEspacio and GHESA, EA developed the basic structural design of the telescope and the detail design and supply of the complete dome and mobile structure with all associated mechanisms and elements for telescope movement and positioning. EA was also in charge of supervising the installation of these elements, and of the associated tests and adjustments

- Basic design of the dome for the next-generation European Extra Large Telescope (E-ELT) with a 42 m diameter primary mirror. The dome, with its rotary movement and shutters, measures 90 m in diameter and will weigh an estimated 3000 t. EA has opted to continue to participate in future phases of this project



E-ELT – 42 m Primary Mirror

- Participation in projects within the EU Framework Programme aimed at demonstrating the viability of generating hydrogen using high temperature processes: HYTHEC (Hydrogen Production by Thermochemical Cycles), INNOHYP-CA (Innovative high-temperature processes for Hydrogen Production) and HYCYCLES (Materials and Components for Hydrogen Production by Sulphur Based Thermochemical



Cycles). EA has been entrusted with coupling these thermochemical processes to the future high temperature reactors or solar furnaces. The projects continue in FP7 Gen-IV activities

- Participation in the design of a pilot CO₂ capture and H₂ production plant in the Puertollano Integrated Gasification Combined Cycle (IGCC) Power Plant, also expected to continue under EU FP7

Acronyms

ABWR	Advanced Boiling Water Reactor
AENA	Aeropuertos Españoles y Navegación Aérea (Spanish Airports Authority)
AP-1000	Advanced Pressurized Water Reactor ~ 1000 MW
APWR	Advanced Pressurized Water Reactor
EBRD	European Bank for Reconstruction and Development
BWR	Boiling Water Reactor
CALS	Computer Aided Logistic Support
DOE	Department of Energy (USA)
EA	Empresarios Agrupados
E-ELT	European Extra Large Telescope
ENSA	Equipos Nucleares, S.A.
ESA	European Space Agency
ESBWR	Economic Simplified Boiling Water Reactor
ESPSS	European Space Propulsion System Simulation (EcosimPro library)
GE	General Electric
GHI	Gibbs & Hill, Inc. (New York)
GCT	Great Canary Telescope
ITER	International Thermonuclear Experimental Reactor
KWU	Siemens – KWU (Nuclear Division)
NRC	Nuclear Regulatory Commission (USA)
PBMR	Pebble Bed Modular Reactor
PHARE	EU programme for technical assistance to countries of Central and Eastern Europe
PWR	Pressurized Water Reactor
SBWR	Simplified Boiling Water Reactor
SGML	Standard Generalized Markup Language
TACIS	Technical Assistance for Commonwealth of Independent States (EU programme)
W	Westinghouse