Available online at www.sciencedirect.com
SCIENCE DIRECT®
Fusion Engineering and Design 69 (2003) 537–544
Fusion Engineering and Design
www.elsevier.com/locate/fusengdes

ITER site selection studies in Spain

M. Medrano [a,*], C. Alejaldre [a], J. Doncel [a], A. García [a], A. Ibarra [a], J.A. Jiménez [a], EISS Vandellós Project Team [a], M.A. Sánchez de Mora [b], F. Alcalá [b], J.E. Díez [b], M. Domínguez [c], F. Albisu [c]

[a] *Laboratorio Nacional de Fusión por Confinamiento Magnético Asociación EURATOM-CIEMAT, Avenida Complutense 22, 22040 Madrid, Spain*
[b] *CIEMAT- Departamento de Seguridad y Prevención de Riesgos. Avenida Complutense 22, 22040 Madrid, Spain*
[c] *IBERTEF Magallanes 3, 28015 Madrid, Spain*

Abstract

The studies carried out to evaluate and select a candidate site for International Thermonuclear Experimental Reactor (ITER) construction in Spain are presented in this paper. The ITER design, completed in July 2001, considered a number of technical requirements that must be fulfilled by the selected site. Several assumptions concerning the ITER site were made in order to carry on the design before final site selection. In the studies undertaken for ITER site selection in Spain, the referred technical requirements and assumptions were applied across the whole of Spain and two areas were identified as being preferential. These areas are on the Mediterranean coast and are situated in the Catalan and Valencian regions. A comparative evaluation based on technical characteristics for the concrete plots, proposed within the preferential areas, has been done. The result of these studies was the selection of a site that was deemed to be the most competitive—Vandellós (Tarragona)—and it was proposed to the European Commission for detailed studies in order to be considered as a possible European site for ITER construction. Another key factor for hosting ITER in Spain, is the licensing process. The present status is summarised in this paper.

Keywords: ITER; Site selection studies; Spain

1. Introduction

In October 2000, the National Fusion Laboratory at CIEMAT undertook the first study carried out to analyse the implications of siting International Thermonuclear Experimental Reactor (ITER) in Spanish territory [1]. At the European Consultative Committee on Fusion (CCE-FU) meeting held in October 2001, the Spanish Delegation informed officially of the decision by the Spanish Ministry of Science and Technology to conduct a study to analyse the possibility of identifying a suitable site for ITER in Spain. CIEMAT was given the task of heading this study. In addition, the CCE-FU invited the EFDA Steering Committee to provide CIEMAT with support similar to that given to CEA when

* Corresponding author. Tel.: +34-91-346-6639; fax: +34-91-346-6124.
E-mail address: mercedes.medrano@ciemat.es (M. Medrano).

0920-3796/03/$ - see front matter
doi:10.1016/S0920-3796(03)00128-5

assessing Cadarache as a possible European site for ITER.

Accordingly, the second study [2] undertaken in December 2001, employed the most restrictive technical requirements and assumptions specified in the ITER design as selection criteria when analysing areas in Spain that could possibly host the device, ranking these in order of preference. As a result, extensive sections of the country were excluded while only a few were selected. These selected areas were then singled out for a third study in February 2002 [3], that focused on analysing several sites put forward by the Valencian and Catalan Regional Governments. In this paper, the technical features of all these sites are considered in detail, taking as reference the technical requirements set out in the ITER design. The conclusion of these studies was that the Vandellós area (Tarragona) in Catalonia is the best candidate in Spain for siting ITER.

The outcome of these studies was that on the 17th of April 2002, the Spanish Government formally offered the Vandellós site to the European Commission for its evaluation as a possible European site and it requested that this site should be considered in the framework of international ITER negotiations. At the EFDA-SC meeting on the 5th of June 2002, the Committee approved a proposal to carry out technical studies on the Spanish Candidate for the ITER Site within the framework of the European ITER Site Study (EISS). At present, a detailed study is being carried out in order to demonstrate that all the generic advantages presented by the Vandellós site can be assessed in the light of ITER and consequently confirm that Vandellós satisfies all ITER site requirements.

2. ITER site technical requirements and assumptions

The ITER site must fulfil a set of technical requirements described in detail in the Plant Design Specification (PDS) [4]. These requirements, which are generic and site-independent, concern the following points:

a) Land: 40 Ha area enclosed within a perimeter. This area must be committed to ITER use for a period of not less than 30 years.
b) Geo-technical characteristics: a soil-bearing capacity for building loads of 25 ton/m^2. For the Tokamak buildings this is to be 65 ton/m^2 (at a depth of 25 m).
c) Fresh water supply: The average daily consumption is estimated to be 400 m^3 (0.2 m^3/min on average, 3 m^3/h at peak).
d) Sanitary and industrial sewage: a sanitary waste capacity for a population of 3000 persons during construction and 1000 persons during operation plus an industrial sewage capacity for 200 m^3/day average.
e) Heat sink: average dissipation to the environment of 450 MW (thermal).
f) Electrical power supply: 120 MW continuous electrical power; two connections from the grid to the site should be supplied.
g) Transport and shipping: the ITER site must be capable of receiving components up to 9 m wide, 8 m high and 15 m long and with a maximum weight of 600 ton.

Furthermore, several assumptions have been made for all ITER design. The adaptation of generic ITER design to the site must be such that minor changes could be needed. In this sense, the selected site should fulfil these assumptions as far as possible. In a first approach to site selection the following assumptions were taken into account:

a) Socio-economical infrastructure: industrial infrastructure must include scientific and engineering resources, manufacturing capacity and construction materials; the competent operating and scientific workforce could be recruited from neighbouring communities; a socio-economical infrastructure which allows the social, educational, cultural and labour integration of several thousand people.
b) Land and topography: 30 additional hectares, adjacent to the compulsory land area, are needed. The site is assumed to be topographically 'balanced' (the volume of cuts and fills to be approximately equal over the stipulated

land area). A maximum elevation difference < 10 m with respect to the mean elevation of the total land area.

c) Geo-technical and hydrological characteristics: the surface soil layer is assumed to be deep enough in order to eliminate the need to remove underlying hard rock for building excavations, except for the Tokamak building (25 m excavation). Ground water assumed to be present at 10 m below the nominal grade.
d) Seismic characteristics: IAEA seismic classification level-SL-2, signifying 0.2 g horizontal and vertical peak ground acceleration.
e) Heat sink: the design is based on mechanical cooling towers (make up water 16 m^3/min)

3. ITER site selection process

The methodology used in the selection study for potential sites was defined by four exclusion criteria. They were based on those ITER requirements and assumptions selected as the most restrictive ones. The exclusion criteria were applied in consecutive order across the whole territory. In this way, extensive areas of the country were promptly eliminated to leave a list of priority areas that could be studied in more detail. The selection criteria used were as follows.

3.1. Socio-economic infrastructure

Areas within a 25–50 km radius around important towns and cities having industrial and social infrastructure, universities, etc. that were accessible by road or rail, and that were well connected to airports were chosen. Areas with easy connection to international airports were classified as priority 1 (see Fig. 1).

3.2. Seismicity aspects

Next, the seismic intensity criterion was applied. After consultation of the 'Spanish seismic areas map', areas exceeding seismic intensity level VIII, which is equivalent to a 0.2 g peak ground acceleration with a return period of 10,000 years, were eliminated, i.e. the Pyrenees and Andalusian regions. Fig. 2 shows the areas remaining after applying criteria 1 and 2.

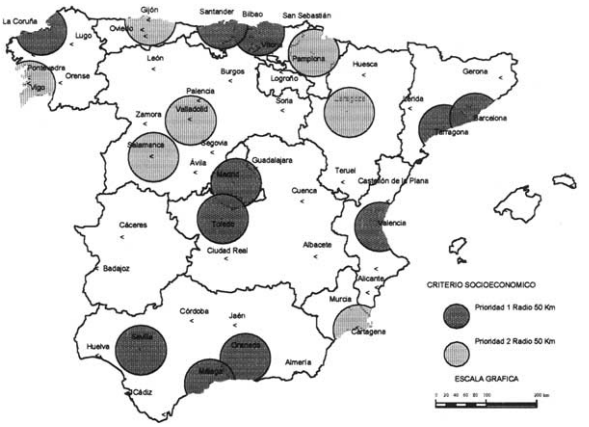

Fig. 1. Selected areas considering socio-economic criterion (priority 1 for the areas in blue and priority 2 for the areas in red).

3.3. Special transport requirements

It has been assumed that the transport of components from their place of origin will be mainly by sea; hence a site close to the coast and not very distant from the off-loading point is

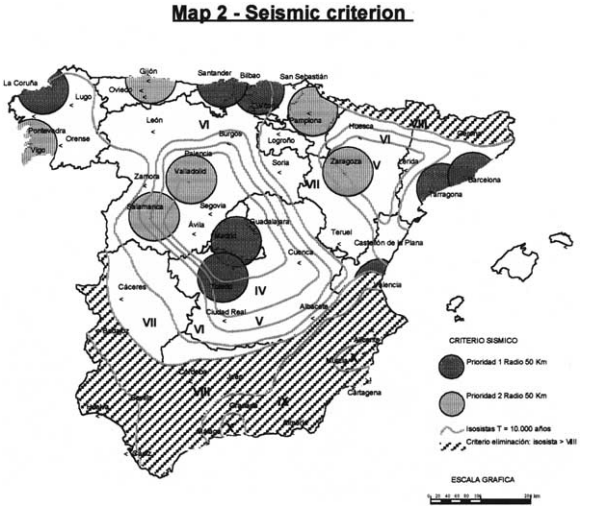

Fig. 2. Selected areas after application of seismic criterion to Fig. 1 (priority 1 for the areas in blue and priority 2 for the areas in red). 'Spain seismic areas Map' has been superposed on the figure.

recommended. Therefore, inland cities were considered to be less suitable (see Fig. 3).

3.4. Electrical power supply

Areas that lacked a dense and reliable electrical grid, or that were not located close to power stations or HV nodes, were also discarded. Hence, eastern (Tarragona, Barcelona and Valencia) and nothern (Bilbao, La Coruña) Spain were considered to provide the most suitable areas. Fig. 4 shows the map of the national power supply grid.

Additionally geotechnical and topographical characteristics were considered and the areas that did not fulfil the soil-bearing capacity and permeability conditions, as well as those located 1500 m or higher above sea level or those with slopes greater than 20% were discarded. Applying these criteria, the Mediterranean coastal areas were deemed to be more suitable than North Atlantic coastal areas. Several factors such as meteorological conditions, the absence of man-made and external hazards, the availability of water for cooling towers, etc. were considered but not taken as reasons for excluding areas in this study. However, these factors were kept in mind when making the final site selection.

The selection study resulted in the identification of two high priority areas for the ITER site, these being:

- Valencia and Castellón area,
- Catalonian coastal region close to Barcelona and Tarragona

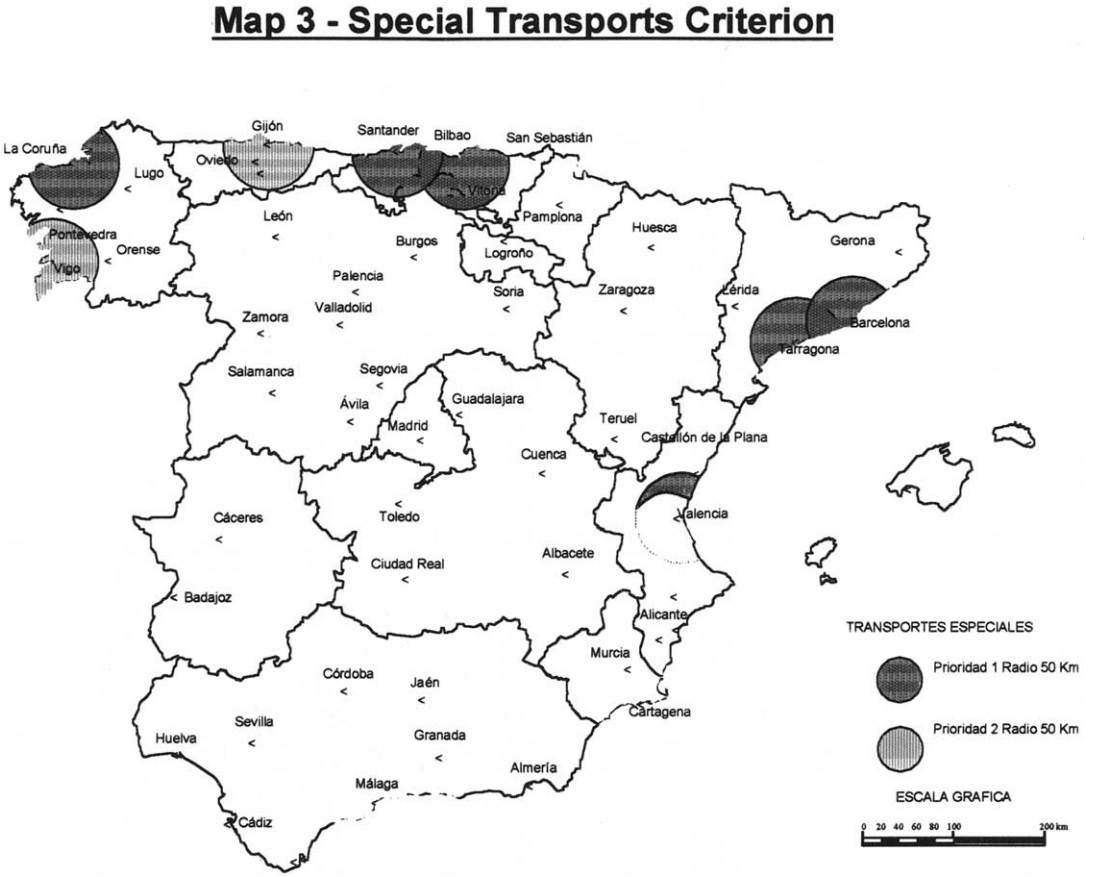

Fig. 3. Areas remaining after applying the Special Transport criterion (priority 1 for the areas in blue and priority 2 for the areas in red).

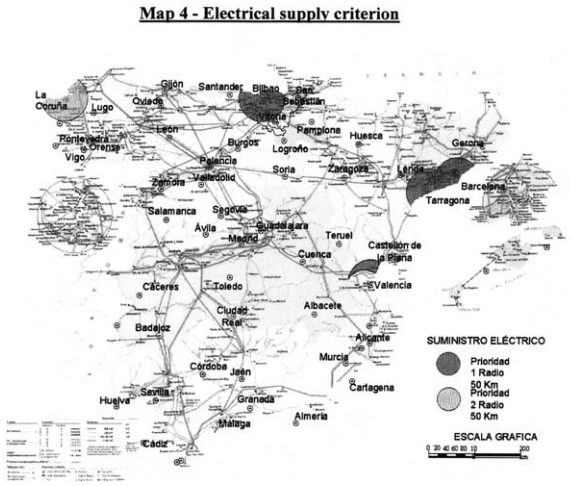

Fig. 4. Selected areas after applying criterion number 4 (priority 1 for the areas in blue and priority 2 for the areas in red). 'Map of the National power supply grid' has been superposed on the figure.

and two with lower priority:

- Atlantic coastal region close to Bilbao,
- La Coruña coastal area in the province of Galicia.

The results of the selection process derived from applying the aforementioned exclusion criteria are shown in Fig. 5.

Fig. 5. Final result selection of areas classified as priority 1 (in blue) and 2 (in red).

4. Preliminary evaluation of the selected sites

In the aforementioned study, the Valencian and Catalonian Autonomous Regions were the areas assigned with highest priority. The Valencian Regional Government initially offered five sites for evaluation but two of these were promptly discarded because of their non-compliance with several requirements. The Catalonian Regional Government offered two sites but for the same reasons only one of these was considered. Hence, the following analysis focussed on three locations:

- Site 1 (Valencia): This is situated in an area located to the west of the N-340 highway and close to the boundary between the provinces of Castellón and Valencia. It is situated about 6 km from the coast, and it lies in an agricultural zone.
- Site 2 (Valencia): This is located 12 km away from the coast, in the valley of the River Palancia. It is an agricultural area with a semi-urban environment with detached houses.
- the Vandellós site (Catalonia): It comprises of land within the perimeter of the Vandellós-I Nuclear Power Plant, which is currently being dismantled, and an adjacent plot. The whole site consists of a net area of at least 70 Ha.

In order to evaluate these three sites, a comparative study involving additional and more detailed technical critera was carried out. The results are summarised in Table 1 and outlined below.

1) The agricultural environment of the sites proposed by the Valencian Government and their proximity to towns or villages makes it difficult to attain the land area required for siting ITER. However, the Vandellós site not only furnished the required space but also the necessary infrastructure due to its proximity to an important industrial area.
2) In terms of the geological and geo-technical characteristics, Vandellós' soil presents sufficient bearing capacity without the need for conditioning. In the other two sites, such

Table 1
Comparative results of the study of proposed sites for siting ITER in Spain

	Site 1 Valencia	Site 2 Valencia	Vandellós Tarragona
Land and Layout	Difficulties to delimit 70 Ha area, due to proximity of several towns	Sufficient space but detached houses exist in the area	70 Ha available without causing interference to the Vandellós-I and -II NPP
Geology and Geotechnics	Medium-low soil-bearing capacity	Medium-low soil bearing capacity of the superficial deposits: soil improvement required for building foundations	Adequate soil-bearing capacity
	Acceptable drainage	Very high bedrock capacity (Tokamak building)	Adequate underground water level
	Slope $<7\%$	Use of explosives for excavations required	Use of explosive for excavations possibly required
	Underground water level is superficial Use of explosives for excavations is required		
Seismicity	Acceptable: peak acceleration <0.16 g for 10,000 year return period	Acceptable: peak acceleration $<$ 0.16 g for 10,000 year return period	Acceptable: horizontal peak acceleration 0.2 g for 10,000 year return period
Drinking water	Guaranteed supply from Sagunto network	Guaranteed supply from Sagunto network	Guaranteed supply from local network
Cooling water	Supply from the sea Need for desalination to be considered Water intake from the coast required Supply-return piping length: 6 km; difference of levels is 60 m	Supply from the sea Need for desalination to be considered Water intake from the coast required Supply-return piping length is 14 km, difference of levels is 130 m	Supply from the sea Need for desalination to be considered Water intake from the coast required Supply-return piping length <2 km; difference of levels: 30 m
Effluents	Necessary to build sewage treatment plant	Necessary to build sewage treatment plant	Necessary to build sewage treatment plant
Electrical power	New facilities required single 400 kV line (15 km) double 220 kV line(15 km) One 400/220 kV auto-transformer in the future Sagunto 400 kV substation	New facilities required single 400 kV line (15 km) double 220 kV line (15 km) One 400/220 kV auto-transformer in the future Sagunto 400 kV substation	New facilities required single 400 kV line (500 m), existing pylons double 220 kV line (500 m), existing pylons One 400/220 kV auto-transformer in the existing Vandellós 400 kV substation
Shipping and transport: Component off-loading	Adaptation needed of existing port accesses and of routes from port to site (construction of new off-loading dock closer to the site is an alternative)	Adaptation needed of existing port accesses and adaptation of the routes from port to site	Construction of off-loading dock by the site or adaptation of the existing harbour at Vandellós II NPP site to be considered
Road infrastructure	Adaptation required of existing road between the site and the off-loading point	Adaptation required of existing road between the site and the off-loading point (high cost foreseen)	Adaptation of passageway below the Valencia-Barcelona railroad required

conditioning could be necessary thus implying some extra costs. The greater excavation effort, would imply extra costs for the Valencian sites, compared to the Vandellós excavation cost.

3) In all three cases cooling water would be drawn from the sea. However, the Valencian sites, which are located away from the coast and above sea level, would require extended piping and additional pumping heads.

4) The additional infrastructure required for the electrical supply was similar in all cases. However, in the case of the Valencian sites, longer electrical lines would be required. On the other hand, pylons from the local substation to the site already exist at Vandellós.
5) From transport and shipping points of view, all three locations may require a new landing dock. However, the Vandellós site did not present any difficulties for terrestrial transport, given its coastal location, while the Valencian sites would require additional civil works in order to cross local motorways and railroads.
6) The results of the seismic and effluent evaluations demonstrated practically no differences between the three sites.

5. Conclusion: Vandellós site

- The systematic studies made in Spain for the ITER site selection point to the Vandellós site as being the most favourable from both technical and economical points of view.On the technical side its main benefits include excellent communications, good accessibility for easy transport of heavy components, proximity to a powerful node in the electric power grid, and strong industrial and socio-economic infrastructure.On the economical side, its principal advantage is that modifications that would be needed to adapt the Valencian sites to the ITER design technical requirements would imply additional costs compared to those at Vandellós.
- Other factors noted include the fact that the Vandellós site could benefit from existent infrastructures in the adjacent Vandellós-I NPP site, which is currently being decommissioned, although their possible use would need to be further studied. The Vandellós area was extensively studied in the past when licensing its two Nuclear Power Plants (Vandellós-I and -II). Their licensing process required perfect characterisation of the zone with regard to geological, seismic, topographic, and meteorological aspects, etc. and such data is available. This fact can facilitate and shorten the licensing process for ITER.

Also, its socio-economic environment is very favourable because of natural conditions such as climate as well as its proximity to important cities such as Barcelona or Tarragona.

6. Licensing process

A preliminary analysis of the ITER licensing process with respect to the Spanish legal framework has been carried out. The ITER project categorisation regarding licensing is established in accordance with Spanish Nuclear Laws and Regulations considering the specific characteristics of the facility as well as the objectives of operation and utilization.

The licensing of ITER in Spain will be subjected to the regulations controlling the use of nuclear and radioactive materials and technology, and furthermore, to the regulations controlling special industrial projects that may have an environmental impact.

Therefore, ITER authorisation concerning the Environmental Impact Statement (EIS) will be undertaken within the competence of the Spanish Ministry for the Environment. With regard to application of Spanish nuclear regulations, ITER licensing processes concerning authorisation or permits will be done under the competence of the Spanish Ministry of Economy and the Nuclear Security Council (CSN).

The licensing of nuclear installations (and 1st category radioactive installations) in Spain follows a multi-step process that includes site, construction, operation, modification and decommissioning permits. This process will also be employed for ITER licensing with the adaptation of relevant documents to the special characteristics of this installation in accordance with *Spanish Regulations for Nuclear and Radioactive Installations*.

The licensing process duration depends on legal administrative periods and deadlines and on the questions/answers period with regulators (this consumes most of the time). The calendar proposed for ITER licensing is considered to be

'realistic' by the Spanish Nuclear Authorities because the Vandellós site is very well known to the CSN and hence provides a 'fast track' for licensing. According to this, groundbreaking for ITER infrastructure works could start as soon as the site permit is awarded (September 2004).

Another important issue is that the CSN has indicated that existing regulations allow to the licensing process to be started before the ILE (ITER Legal Entity) has been created. In this way, the necessary interaction with Spanish Authorities for initiating the licensing process can be carried out by CIEMAT on behalf of ILE.

7. Conclusions

- The studies carried out for ITER site selection in Spain have considered the criteria set out by ITER requirements and assumptions.
- The results point to the Vandellós site as being the most favorable from technical points of view. The main benefits include excellent communications, good accessibility for transport of large and heavy components, proximity to a powerful node in the electric power supply grid, an important industrial and socio-economic infrastructures and its coastal location.
- The site is very well characterized with regard to geological, seismic, topographic, and meteorological aspects, etc. due to the fact that two Nuclear Power Plants were licensed previously and extensive studies were made at that time. For this reason the Vandellós site is very well known to the Nuclear Regulatory Authority of Spain (CSN) and hence provides a 'fast track' for licensing. Groundbreaking for ITER infrastructure works could start as early as September 2004.
- The required interactions with the CSN for initiation of licensing process can be carried out by CIEMAT on behalf of ILE.

References

[1] IBERTEF, Ubicación de Iter en España, Octubre 2000.
[2] IBERTEF, Iter en España: zonas para posibles emplazamients, Diciembre 2001.
[3] IBERTEF, Iter en España: evaluación preliminar de emplazamientos, Febrero 2002.
[4] Iter Final Design Report: Plant Design Specification, July 2001.