ITER AT CADARACHE

MH 27nov02

Literature:
ITER generic safety report (GSSR)
[jan01] EFDA Preliminary Site Assessment report 17jan01 (paper only)
[may01] Summary of the findings by the European ITER Site technical Study group, EFDA (01)-12/5.6
[sep01] EFDA, Cadarache as a European Site for ITER, Report on the Technical and Socio-economic Aspects
[sep01 Wash] Cadarache: a site for ITER, J.Jacquinot, Fusion Power Associates Annual Meeting, Washington, 25-26 September 2001
[apr02] EISS Cadarache Summary

History
1958 2nd international conference on the use of atomic energy for peaceful purposes, Geneva (declassification of fusion research, EC6 included fusion in R&D programme, EURATOM-CEA association for fusion created)
1959 Cadarache was founded (fission only)
1968 fusion most promising, French fusion in Fontenay-aux-Roses and Grenoble
1980's second generation (JET, TFTR,. JT60,..), EC prepares for NET
1985: ITER (Gorbachev, Reagan, Mitterand)
1988 - 1990 ITER CDA (conceptual design activity)
1992 - 1998 ITER EDA
1998 - 2001 ITER EDA extension, „ITER light" for half cost
2001 - ITER CTA (coordinated technical activities), 18 months
? ITER COEDA (construction, operation, exploitation and decommissioning activities)
? 2003 ITER Joint Implementation Agreement
After ratification of the ITER JIA, establish ILE (ITER legal entity)

ITER EDA (engineering design acitivities, 1992 - 2001):
- Under framework of the ITER Agreement and Protocol, under auspices of IAEA
- reference design **("generic design")**
- **set of needs** (PDS: plant design specifications) to be satisfied by any proposed site (specified in oct01, published jul01)
    - some obligatory (compulsory): **site requirements** (demands on the site derived from the design)
    - some more liberally: **design assumptions** (used for design and cost estimates until the actual ITER site is known)

Legal Implementation
- started 16nov00
- European Council of Ministers asks Commission to "conduct negotiations on the establishment of an international framework allowing the ITER EDA Parties and qualified third countries to prepare jointly for the future establishment of an **ITER Legal Entity (ILE)** for ITER construction and operation, if and when so decided"

It is assumed that ILE (Iter Legal Entity) will be the operator
- CEA until ILE is created
- Responsible for safety and environmental impact of installation from beginning of construction to the final step of decommissioning
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Time Schedule:

- Site decision 2003
- Start construction 2005
- Start operation 2013

EISSG (European ITER Site Study Group):

- Technical Working Group, established by EFDA oct00, chaired by EFDA Technology Associate Leader (R. Andreani)
- Reports to CCE-FUSION,
- Managed as a European project,
    - CEA,
    - other Associations (ENEA Frascati, FZK, IPP, NFR Studsvik, UKAEA Culham)
    - strong involvement of European Industries
- Composed of experts from
    - EFDA CSU Garching (Lackner, Gulden, Maisonnier, Murdoch)
    - Associations

  with participation of EC (J.P.Rager)
  in consultation with ITER JCT (Joint Central Team) Ch. Gordon, R. Haange

EISS (European ITER Site Studies)

- ToR
    - Goal:
        - Establish compliance of European site(s) with ITER-FEAT technical requirements
        - Identify key elements for the site specific licensing procedure
        - Examine site specific aspects of the ITER construction and operation costs
        - Evaluate social and infrastructure impacts of the project
        - Assist the European ITER negotiators in providing further info on the above items as required.
    - Activities: 4 Topical Areas, 13 Tasks *(see below)*
- Work Plan in [jan01]
    - 3 Work packages (each with task, deliverable, date)
        - Preliminary site assessment
        - Documentation for site proposal (this is [sep01])
        - Planning and cost estimate
- "in the first instance": site studied: Cadarache

EISS 2001 and 2002

2001

- Budget: 5 M€,
- Technical Assessment, Start of licensing procedure, socio-economic studies

2002

- Budget 10 M€
- Licensing procedure continued, ITER/site adaptation studies, design of infrastructure

EISS Tasks

First batch: 4 Topical Areas, 13 Tasks:

Requirements and assumptions for the various elements are justified in the **Bases statements**. These statements explain the rationale for their inclusion. [sep01p39ff]

1. Technical Requirement (CEA)

    a. Land (compliance of Cadarache regarding the requirements and design assumptions related to the land, …)
       Requirement:
       Basis:
    b. Seismic issues, external hazards and consequences (review Cadarache characteristics regarding the seismic situation and the risks of external hazards. If necessary design modifications will be studied, their cost implication estimated, safety aspects will be reviewed..
       Requirement:
       Basis:
    c. Heat sink and water supply (compliance of … regarding …)
    d. Electricity supply
    e. Transport and Shipping (… several means shall be considered. A different segmentation …)
2. Safety and Licensing (CEA)
    a. Review of accidental and operation safety analysis (review and sum up the existing safety documentation with the presentation required by French Safety Authorities, identify missing parts,… Emphasis on ALARA)
    b. Definition and implementation of a quality assurance procedure (which is in accordance with the French Safety Authorities requirements)
    c. Effluents and releases (Assess and optimise … on the basis of ALARA …)
    d. Waste management and decommissioning
    e. Tritium transport and control (discuss and propose a suitable way for the tritium storage, transport and control .. take into account the experience of JET and other T laboratories like FZK. For each item a review of the main options, taking into account the local regulations… optimised proposal… different hypotheses to study T releases)
3. Socio-economics (Hamacher)
    a. Socio-economic infrastructure (estimate the socio-economic potential of the region, the fall-out of the construction of ITER in Cadarache)
4. General aspects of costing (UKAEA)
    a. cost estimate (establish ITER site specific costs, assume Cadarache)
5. generic task
    a. documentation and synthesis

Second batch forseen for 2002-2003

- licensing
- site design

Licensing

Licensing in France

- licensing required for any INB ("installation nucléaire de base", based on inventory of radioactivity; ITER: T and expected waste generation during lifetime)
- licensing process: two decisions at government level:
    - DAC (decret d'autorisation de création) required to start construction, to be signed at least by minister for environment and for industry
    - DARPE (décret d'autorisation de rejets et de prélèvements d'eau) required to start operation, to be signed by ministers for environment, industry and health
- STATUS (apr02): DAC and DARPE will be started at beginning of 2003
- licensing procedure: dialogue between Safety Authority (DGSNR, Direction Générale de la Sureté Nucléaire et de la Radioprotection") and ITER Operator

Road Map for Licensing (total 5y):

1. DOS (Dossier d'Options de Sureté),

- STATUS (apr02): completed at end of 2001, recently submitted by CEA to DGSNR, advice expected by end of 2002
- 1y
- concise technical document, defines major risks and proposes means to avoid them,
    - General background and objectives, description of site
    - Plant description (background info on fusion, functional description of sub-systems
    - Overall objectives of Safety Implementation (radioprotection principles, dose targets, no-evacuation-objective in case of design basis accidents, overview beyond design events
    - 4 functions of nuclear safety:
        - Control of nuclear reaction (fusion: no run away)
        - After heat removal (fusion: low level)
        - Confinement of all radioactive material (major point for fusion)
        - Control of personnel exposure (ALARA principle)
    - Safety approach:
        - Definition of the safety objectives
        - Identification of consequent safety functions
        - Definition of the technical safety options which will maintain the safety functions.
    - Safety Principles
        - ALARA (as low as reasonably achievable, economic and social factors taken into account)
        - Defence in depth (overlapping levels of safety provisions, a failure at one level would be compensated by other provisions. Prioritay to preventing accidents…)
        - Passive safety (shall be given special attention.
        - Consideration of ITER safety characteristics (deploy fusion's favourable safety characteristics to the maximum extent feasible. Address the experimental nature of the facility. …)
        - Review and assessment (safety assessment to be an integral part of the design process.
    - Technical Options for Safety ("defence in depth")
        - Control of the reaction,
        - Control and removal of residual after-heat,
        - Control of radioactive material and releases (confinement, gaseous releases, liquid effluents, production of radioactive waste (minimise and manage waste), decommissioning (manageable quantities and acceptable doses for workers)
        - external hazards,
        - loss of electrical power,
        - fire,
        - chemical risk: prevention and mitigation against hydrogen risk,
        - risk during handling heavy components,
        - human factors,
        - conventional risks
    - Quality assurance
- prepared by plant owner, assessed by SA;
- existing generic table of content for all INB at Cadarache Site.

2. RPrS (Rapport Préliminaire de Sureté), PSA (preliminary safety analysis)

- STATUS (apr02): preparation at beginning of 2002, under auspices of EFDA
- 2y, submission expected end of 2003
- detailed description and comprehensive safety analysis of INB
- assessed by the technical services (IPSN, Institut de Protection et de Sureté Nucléaire) of the SA, advice by national advisory board "Groupe Permanent".
    - Radiological source terms (T, neutron activated products in structure and dust, corrosion products in cooling water,…)
    - Non-nuclear hazardous materials - chemically toxic (Be,..) or reactive (H2,..)
    - Energy source terms (plasma, magnets, activation decay heat, coolant thermal energy, chemical energy)
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1.+2. Public Debate (DP, Débat Public)

- discussion at national level on socio-economic and environmental consequences (merits and problems)
- any association or group of elected people may ask for this DP for any new large project or major installation, including nuclear ("loi Barnier 95/101, loi sur la démocratie de proximité, Feb.02)
- can be initiated in parallel to DOS and RPRS, 1--2y
- cannot last more than 6 months
- an independent commission is in charge of surveying the process and giving conclusions

3. Public Enquiry Procedure (Enquete publique)

- 2y
- consultation process limited to the local communities (15km radius) on the external effects
- Public Enquiry Commissioner must give opinion. No construction if not positive.

Decommissioning provisions

- CEA would take care of decommissioning and waste management after Definitive End of Operation
- Requires agreement, financial provisions, technical guidelines

Site requirements (result: 2 not fulfilled, can be overcome at modest cost)

General Layout: Within Cadarache Centre

- Topography
- Dominant wind
- Geology (drillings)

Electricity Supply

- **Capability of the network to supply reactive power compensation is lower than on the generic site**
- Active power of 500 MW needed, of 1000 MW available
- interconnection of lines (225 und 400 kV), 400 kV line at site for Tore Supra, nodes at 5 and 8 km
- hydroelectric power nearby (emergency supply?)

Heat Sink and Water Supply

- 3 water canals (irrigation and hydro electricity)
- quality, cost/m3, investment for piping and pumping/gravity

Transportation and shipping

- 75 km from seaside
- transport by road (3 days, major adaptations) or waterway (10 days, requires adaptation)
- 18 20° vacuum vessel sectors instead of 9 40°?

- 15 kg T from off-site sources (needs inventory tracking and accounting)

Seismicity

- **higher than on the generic site** (higher than average in F, lower than in other Mediterranean countries)
- 18 INB in operation in Cadarache, most of them according to 1981 safety rules (RFS: Règles fondamentales de Sureté), some using older RFS, needs refurbishment and requalification. RFS are actually under revision, no major changes expected regarding seismic levels
- may require adaptation of design of ITER buildings *[Loviisa?!]*

Effluents and releases

- main concern
  - T (elemental, oxide)
  - Activated corrosion products
  - Be
- Release pathways
- Control system (mainly water and atmosphere detritiation system, atmospheric filtering system)
- First estimate: meet Cadarache criteria, but ALARA

Waste Management and dismantling

- operating and decommissioning phases
- 3 types: activated, tritiated and both
- recycling or disposal (France: no clearance level for very low level waste from INB)

Cost

- additional infrastructure required to host ITER: 100 M€
- includes transport, site preparation,…

Socio-Economy

Socio-economic environment (1996)

Population

- 4.5 Mio residents
- infrastructure
- standard of living

Infrastructure

- roads, airport
- nearby cities

Accommodation

- hotels (tourist area)

Scientific and industrial capabilities

- research organisations in region (CEA, CNRS, …)
- CEA Cadarache: 3000 permanent researchers, 2000 from external companies, 400 M€ annual budget, research on fission, fusion, research on plants, bacteria and renewable energy sources (CEA: 16.000 people working, 10 research centres, aims are … designing, manufacturing and maintaining nuclear weapons …)
- Location of the major part of the CEA-EURATOM-Association, Tore Supra (since 1988, first super conducting in world), 300 people
- 6 technology centres nearby
- well represented sectors: building, electronics, chemistry, mechanics, metallurgy, nuclear industry,..

Education

- pre-school establishments,
- primary, secondary (public, private), international high school with 1000 pupils, (??potential for more students),

- 10 universities within 250 km with 200.000 students
- local engineering schools training 6000 engineers/y

Health
- hospitals, clinics, …4,5oo beds in medicine, 3.300 in surgery, 550 in maternity, 1,500 in psychotherapy
- medical research

Labour resources, employment
- 1,500.000 workers industry (200.000), services, construction, agriculture
- heavy industries near sea
- many contractors with skilled teams
- large companies in construction and public work industries
- job opportunities for family members

Cultural environment, leisure, tourism
- historic sites, museums, festivals,…
- Mediterranean,…

Socio-economic Study

Economic Benefit
- quantitative analysis of the benefits, especially impact on employment and economic performance
- qualitative benefits: new specialised companies, spin offs, brain gain,…

Methodology:
- improve study on interrelationship of R&D and economic performance, especially in the regional context.

Public participation
- information on planning, construction, operation of ITER
- information on benefits of fusion to the whole of mankind
- alleviate any possible concern
- note: local population familiar with presence of nuclear establishment
- Make use of Porto Torres
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Conclusion:
- Cadarache fulfils all ITER site requirements
- Cadarache fulfils most of the design assumptions

Site Requirements (Result: fulfilled):

Land
- Area: 40 hectares for at least 30y
- Geotechnical; soil bearing capacity of 25 t/m2 for buildings, 65 to a depth of 25m for tokamak building
- Sanitary waste for 1000 people, industrial waste 200 m3/day

Seismic issues, external hazards and consequences

Water supply
- High quality water (drinking, make up,..)
- 0,2 m3/minute average, 3 peak, daily average 200m3,

Heat sink
- low quality water
- requirement: disperse 450 MW thermal energy to environment
- basis: 1200 MWth for 500 sec
- 1.5 mio m3/y for cooling water, equal to total consumption of present Cadarache site.

Electricity supply

- 150 (120?) MW continuous, 2 connections to site, no interruptions due to maintenance

Transport and Shipping

- Max size of components (not simultaneously): 9x8x15m
- Max weight of components: 12 packages of 600t, 100 of 100 to 600t
- Basis: only poloidal field coils manufactured on site.

Regulatory and Decommissioning

- practicable licensing frame work to permit ITER to vbe build and operated
- off-site matters: T transport, storage of activated material

Design Assumptions (Result: Depending on the assumptions the situation can be more favourable (benefits identified) or less favourable (necessary compensatory measures identified) than the generic site)

Land

- additional 30 ha close to site
- maximum elevation change < (+-)10m
- no hard rock removal (except tokamak building)
- ground water level 10m
- seismic characteristics (max ground acceleration 0.2g)
- meteorological characteristics

Heat rejection system:

- Water supply: fresh water 16m3/min average
- Industrial sewage 3000 m3/day

Energy and electric power

- electric power reliability
- pulsed electric supply (a high voltage line to supply pulsed loads)

Transport and Shipping

- …

External Hazards and Accident Initiators

- …

Infrastructure

- access to industrial infrastructure, workforce, ..
- socio economic infrastructure: communities not further than 50km,..

Construction Phase

- water, sewage and power supplies for 3000 people construction force

Scientific and Industrial Background (Result)

Industry in the region

- 40% of national microelectronics production
- 35% of French oil refining
- 25% of steel production
- …
- innovative companies (30 startup / y)
- …
- building sector

Scientific resources

- 11.000 researchers, second after Ile de France in public research (6500), third in private research
- regional spending on R&D

Professional resources, jobs

Socio Cultural Aspects (Result)

Location, Access, Transport
Climate
Welcome Centre is foreseen

- welcome for personnel arriving from abroad
- deals with education, housing, administration (tax, drivers license,..), information and assistance, employment for spouses
- bi- and trilingual people

Education

- present French school system
- Study under way about changes in the existing infrastructures to be recommended (new international establishment,..)

Housing

- very large and highly diversified housing pool, high level of availability
- 500 new real estate agencies in 1999, 600 in 2000

Health Care

- one of the best in the world
- #of beds…