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newsletter

EUROPEAN FUSION DEVELOPMENT AGREEMENT

Issued by the EFDA Close Support Unit Garching

Content

http://www.efda.org

FOREWORD

In July another step was made towards the ITER fusion reactor. The current in the superconducting **Toroidal Field Model Coil**, manufactured in the EU in the framework of the R&D activities for the "next step" machine, reached the operational value of 80 kA. This positive result is very important with regards to ITER operation.

Other good news reached us from the **Madeira Conference**: Dr. Umberto Finzi explained in his message why the prospects for undertaking the Next Step in Fusion development have never been in the past as good as they are today. And while the ITER Negotiators meet in Canada, Spain is going to analyse the possibility of offering a site for ITER.

EFDA attendance to the **Sustain 2001** exhibition allowed us to discuss energy issues with the large number of visitors who paid a visit to our stand. The result of such discussions supports our confidence to consider fusion as one energy option for the future.

LATEST NEWS FROM ITER

European Council of Research Ministers ; October 30th, 2001

The French Minister for Research, Mr. Roger-Gérard Schwartzenberg, invited the European Union to define the conditions, in particular their financial aspects, which will be proposed to the Member States that are candidates for hosting ITER, before they enter into a defintive engagement.

In that context, Mr. Schwartzenberg asked that the French proposal to build ITER in Cadarache will be taken into account in this process and that a European position will be prepared.

Spain

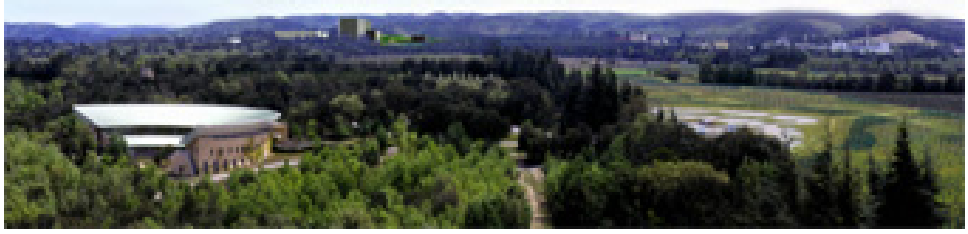
The Spanish Ministry of Science and Technology has decided to launch a detailed study to analyze the possibility of offering a site for ITER to the European Union.

CIEMAT (Centro de Investigaciones Energéticas Medioambientales y Tecnológicas) will be responsible for this study. This process may result in a formal offer from Spain to host ITER.

Canada

Delegations from Canada, the European Union, Japan and the Russian Federation met in Toronto at the beginning of November to begin formal negotiations on the joint implementation of the ITER project.

More information from the official Press Release on page 4.



READY FOR ITER

TOSKA

Toska (Toroidal Spulenanlage Karlsruhe) is a large test facility which uses LCT (Large Coil Task) coils for testing superconducting magnets.

More Information

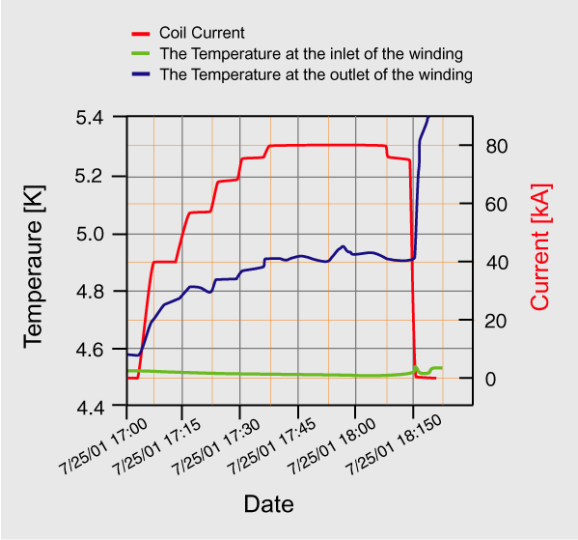
http://hikwww4.fzk.de/itp/mkf/mkf_e2.htm

Toroidal Field Model Coil (TFMC)

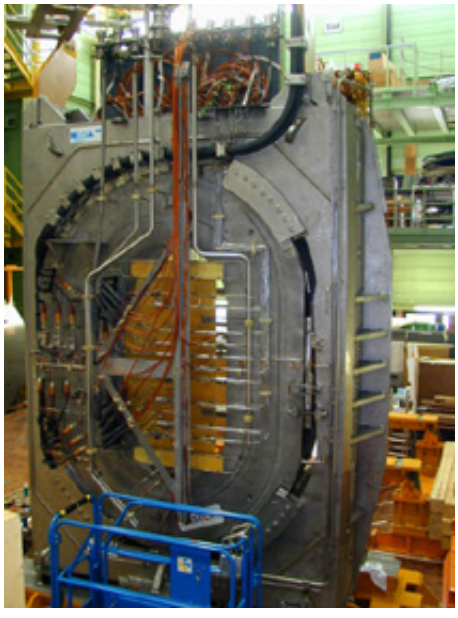
The European research laboratories working on fusion have conceptually designed the TFMC. Ansaldo GEC-Alstom (now Alstom) Accel Noell (AGAN), a consortium of European companies, have completed the engineering design of the coil. They also manufactured the TFMC under the management of EFDA/CSU (Close Support Unit) Garching.

The Toroidal Field Model Coil has reached its maximum operating current

July 25, 2001 was an important day for fusion: the Nb_3Sn superconducting ITER Toroidal Field Model Coil (**TFMC**) - installed in the **TOSKA** facility at the Forschungszentrum Karlsruhe - reached the maximum allowed current of 80 kA, and a maximum magnetic field of nearly 8 T (see graph below).



After having achieved an operating current of 57 kA a few days before, the power supply control system was readjusted. Afterwards the test programme was resumed and 69.3 kA were reached. This value is already above the nominal current of the toroidal field coils, which are planned for the ITER machine.



The ITER Toroidal Field Model Coil

On the 25th July, when the TFMC was ramped up to the maximum current of 80 kA the situation was clear: the superconductor and the joint resistances behaved as expected, as well as the temperature increase in the structures during fast ramp down and safety discharge.

The NbTi busbars carried 80 kA at a maximum magnetic field of about 3 T and at a cryogenic temperature of about 5 K. At that field the joints behaved better than expected. These results are a preliminary confirmation that the design of the ITER Poloidal Field Coils is viable.

The testing of the coil will extend into next year. The test programme will explore the operational limits of the coil and validate the design codes. Both are needed to optimize the ITER cost and operating parameters space.

EDA COMPLETED

ITER at the start of Negotiations towards Joint Implementation

Following the end of the Engineering Design Activities (EDA) in July 2001, all the essential elements are now available to make a decision to construct ITER. The final design report describes a complete engineering design of ITER, which allows a realistic assessment of its feasibility, performance and cost at a generic site.

In parallel, the ITER Parties have explored the issues of how to establish the contractual arrangements between future international partners in ITER, and in particular the creation of an ITER Legal Entity (ILE) at a particular site, and the establishment and formal acceptance of all commitments by host and participating countries during construction, exploitation and decommissioning.

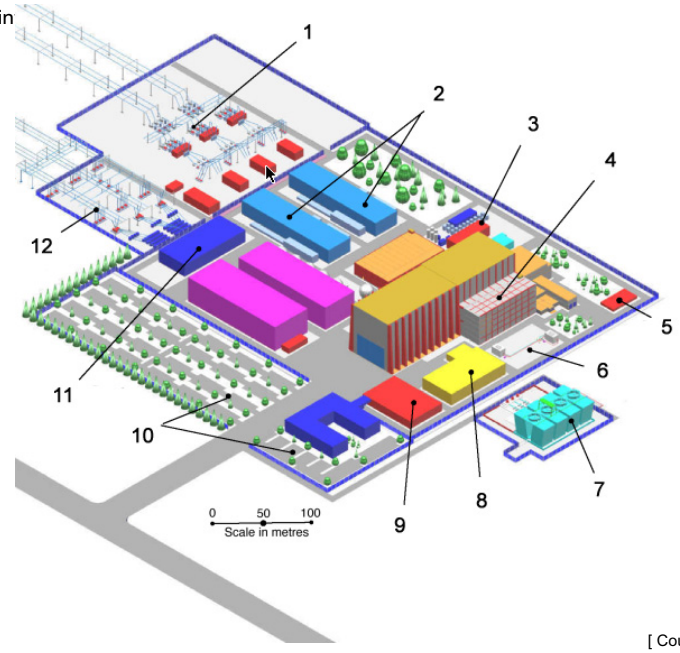
Quadripartite (Canada, European Union, Japan and Russian Federation) meetings on Negotiations on the Joint Implementations of ITER have begun. The first formal Negotiation Meeting was on 8-9 November 2001 in Toronto, Canada. These Negotiations include selecting the site, and agreeing how cost will be shared.

The negotiators are supported on technical aspects by Coordinated Technical Activities (CTA) which maintains the integrity of the project and are preparing for joint construction and operation.

The timescale for the Negotiations foresees that the government of each Party interested in hosting ITER will offer a site in 2001, leading to a preferred site before the middle of 2002, and further development of design adaptations for the preferred site up to the end of CTA at the end of 2002. The Implementation Agreement should be initiated at the start of 2003. Formal signature (and/or ratification) will take place in 2003.

There is an undisputed need for a burning plasma experiment integrating the appropriate physics and technology at the center of the fusion development strategy, and ITER fulfills this role. The objectives of the EDA have been fully met and the Parties have approved the ITER design. The fusion programme is scientifically and technically ready to take the important ITER step.

Sharing costs and pooling expertise have allowed the EDA Parties jointly to undertake tasks that would have been beyond their individual financial and technical capacity. They have developed a mature and wide-ranging capacity for successful focused international joint work. The start of negotiations is a very positive step in their commitment to jointly implementing ITER in a broad-based in



[Courtesy of ITER IT]

Engineering Design Activities (EDA):

The result is documented in the ITER Final Design Report (July 2001).

For a summary check the site:

http://www.iter.org

ITER - SITE

1 Pulsed Power Supply Area
2 Magnet Power Conversion Buildings
3 NB Injection Power Supply Complex
4 Tritium, Vacuum, Fueling & Services Building
5 Gas Store
6 Cooling water-pumping station
7 Hot Basin & Cooling Tower
8 Site Services Building
9 Control Buildung
10 Vehicle Parking
11 Emergency Power Supply Building
12 Steady-State Power Supply Building

ITER NEGOTIATIONS

For further information on the Canadian site see:

www.itercanada.com

www.iterinstitute.com

www.itercommunity.com

Formal Negotiations Begin to Implement the ITER Fusion Project

Delegations from Canada, the European Union, Japan and the Russian Federation met in Toronto this week to begin formal negotiations on the joint implementation of the ITER project. ITER is the world-leading international collaborative scientific and technological project with the goal of taking the next major step in the development of fusion energy as a safe, clean and sustainable energy source for our planet.

The Toronto negotiations were the first in a series that is expected to lead, by the end of 2002, to an agreement on the joint implementation of ITER.

This agreement will govern, under international law, the construction, operation and decommissioning of ITER. Matters covered in the discussions also included the site-selection criteria and process, the cost sharing and procurement allocation schemes.

This first round of negotiations followed preparation meetings in Vienna in July, and in Moscow in June, where Canada presented its bid to host the ITER project. Other site offers are under consideration by the European Union and Japan. Earlier this week there were a series of discussions by experts supporting the negotiations, including international workshops on aspects of the Canadian site offer to host ITER.

The participants in the negotiations took important first steps on a variety of issues, and plan to hold the second round of negotiations in Japan in January of 2002.

[Joint communique, Toronto November 8, 2001]

NEXT STEP IN FUSION DEVELOPMENT

"Prospects have never been as good as they are today"

At the European Physical Society Conference on Plasma Physics and Controlled Fusion, 18 - 22 June 2001 in Madeira, one of the speakers was **Dr. Umberto Finzi.** His address concentrates on the European Fusion Programme and ITER and describes the developments which are still relevant to the current situation.

"Those of you who listened to my short messages at the IAEA Conference in Sorrento or at the SOFT Conference in Madrid might remember that I said that the European Fusion Programme was reaching a branch-point.

A branch point between an upper trajectory leading via a Next Step and Demo to the Fusion reactor and a lower trajectory decaying to a purely academic plasma physics programme without any energy producing ambition in a foreseeable future.

In fact we must always keep in mind that a European Fusion Programme costing 500 Million Euro per year is not sustainable if it does not aim at the development of a new energy source.

But events after Sorrento indicate clearly that we are starting to take the upper trajectory.

The first important event which took place after the Sorrento Conference was the approval in November 2000 by the Council of Ministers of the EU of a mandate to the Commission for the negotiations with Japan, Russia and other possible partners of the International Legal Entity for the possible construction of ITER. This will allow us to continue Co-ordinated Technical Activities on ITER, after the end of the EDA.

The scope of the conference is to present and discuss both theoretical and experimental results in the field of plasma physics and fusion research.

The second important event was the informal meeting of the Council of Ministers held on 19th January of this year. The basis for the discussion was a four scenario document in which scenario 1 was essentially an orderly closing down of the Fusion Programme, scenario 2 was the reduction of the programme on a purely scientific programme with very relaxed reactor ambitions, scenario 3 included the construction of ITER somewhere in the world in the frame of international co-operation, scenario 4 included the construction of ITER in Europe, again in the frame of international co-operation. The important information is that none of the 15 Ministers (or ministerial representations) was in favor of either scenario 1 or 2: they all opted for scenario 3 or 4 or for a mixture of these two. The Portuguese minister, Professor Gago, I am pleased to mention it here in Madeira, proposed even a scenario 5: build ITER in Europe, open to international collaboration, but essentially as a European initiative.

The third important event was the proposal by the Commission to the Council for the 6th Framework Programme i.e. for the years 2003-2006. This proposal was made at the end of February and the corresponding specific programme proposal was sent to the Council recently, at the end of May. A fact of historical importance for the Fusion Programme is that these proposals include, from the programme point of view, the possibility to participate in the construction of ITER, and from the financial point of view, 200 Mio EURO which correspond to a substantial participation in construction expenditure, if the construction of ITER starts, as it is expected, in the second half of the 6th Framework Programme that is in 2005-6.

The overall financial contribution of the Community to fusion activities in Europe is proposed to be of 700 Mio EURO. The spirit of this proposal is to concentrate Community money on joint activities such as JET and ITER and to hand over to national authorities a large share of the burden for the financing of national activities. This transition is necessary in order to be able to move on to the Next Step in fusion development and has to be started already at the beginning of the sixth Framework Programme.

Now many things depend on the ITER negotiations. The situation with ITER is that a quadripartite meeting of the negotiators was held in Moscow on 7 and 8 of June. Before the meeting there was great suspense because only the Europeans and the Russians had a mandate. The announcement by the Canadian ambassador that the Canadian Federal Government was officially proposing Clarington as a site for the construction of ITER, was welcome by all as another very important good news.

Other good news are expected now: concerning sites in Europe and Japan and perhaps - why not? - about the joining of another large partner to the negotiations.

In conclusion I think that at the world level the prospects for undertaking the Next Step in fusion development have never been in the past as good as they are today.

In the meantime the European Programme is thinking how to restructure itself in order to participate in the construction of ITER. The creation of EFDA is recent. It has worked successfully as it is shown by the fact that we were able to operate JET with an entirely new formula. There are bureaucratic aspects, which can be improved, and the whole comitology system has to be redesigned and simplified. But this will be the subject of Professor Varandas' speech."

Dr. Umberto Finzi is the Principal Adviser to the Director General for Research in the European Commission, in charge of thermonuclear fusion. In this role, he contributes to define and implement research policy in fusion, in consultation with the Director responsible for "Research actions for Energy".

Umberto Finzi is also an EU representative on the ITER Council and the International Fusion Research Council of the International Atomic Energy Agency (IAEA.)

Any Questions?
The editors will pass on your e-mails to Dr. Finzi!

federico.casci@efda.org

THE EUROPEAN SPIRIT AT WORK

Nineteen European laboratories participating in EFDA and two US laboratories contribute actively to the JET enhancement projects.
The EU laboratories are:

CEA Cadarache
CIEMAT Madrid
CNR Milano
CRPP Lausanne
DCU Dublin
ENEA Frascati
ERM/KMS Bruxelles
FOM Rhijnhuizen
FZJ Jülich
FZK Karslruhe
HAS Budapest
IAP Wien
IPP Garching
IST Lisbon
RFX Padova
SCK-CEN Mol
TEKES Finland
UKAEA Culham
VR Sweden

The US laboratories are:

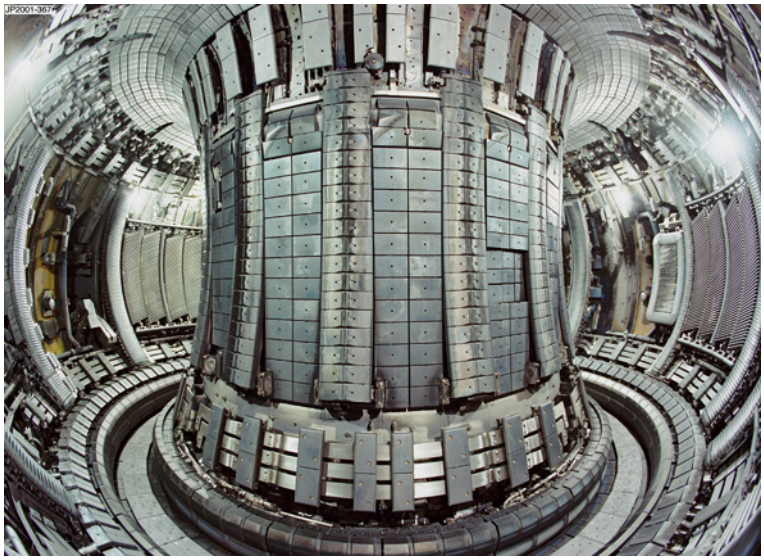
PPPL
ORNL

JET Facilities under EFDA

The use of the JET facilities under EFDA since 1 January 2000 has reinforced cooperation between the European laboratories involved in fusion research.

The experimental programme on JET is organised in campaigns, with scientists coming to the Culham site (UK) for limited periods. Most of the complementary work, related to the preparation of experiments, data analysis and modelling, is conducted from their home laboratories. The scientific work is organised in Task Forces under the coordination of Task Force Leaders, all of whom belong to and are based in the European laboratories associated to EFDA. JET is now used in a way which is closer that in other fields of physics research, e.g. particle physics: a limited number of large facilities are used jointly by decentralised scientific teams with on-site services, such as operation of the facility and various support functions.

This new method of working for the fusion community has been successful during the 2000-2001 Campaigns, with more than 300 European scientists and several tens of non-Europeans involved . The 2002 experimental campaigns, due to start in March 2002, have triggered a high degree of scientific interest in the fusion laboratories, as demonstrated by the participants in EFDA who submitted 333 scientific proposals including 307 experiments for the 100 experimental days foreseen!



New divertor configuration after the 2001 shutdown

This new spirit is clear in all JET activities under EFDA. In particular, the first enhancement projects initiated under EFDA in 2000 are now coming to fruition. Seven projects for new or upgraded diagnostics are nearing completion for the start of the 2002 campaigns and five others should enter into operation during the year. New enhancements are ongoing for improved real-time control of steady state plasmas and extreme plasma shaping, key issues in preparation for ITER operation. Improved plasma fuelling systems will also be available in September 2002, and at the end of 2002 the upgrade of one of the two JET neutral beam injectors will provide an increased plasma heating capability of 7.5 MW. Other enhancements are ongoing to further improve JET's experimental capabilities on the medium term.

Following similar principles to those applied in the scientific programme, Project Leaders belonging to European laboratories lead decentralised teams for the design and procurement of the enhancements. A strong link is established with the JET Operator, UKAEA, responsible for the operation, maintenance and safety of the facilities, through nominated operator representatives. A light overall coordination is provided under EFDA.

Through the success of the first experimental campaigns, the preparation of next year campaigns, the successful achievement of the first enhancement projects and the continuation of medium term enhancements, the fusion laboratories have demonstrated a strong capabilitiy to work efficiently together sharing efforts and responsibilities and optimising the collective use of their various competences.

WENDELSTEIN 7 - AS

First Divertor Operation in a Wendelstein Stellarator is Successful

Promising results in Wendelstein 7-AS at the Max-Planck-Institut für Plasmaphysik (Association EURATOM-IPP) in Garching: an essential auxiliary component - the divertor - was installed for the first time in a Wendelstein stellarator. Its function is to protect the plasma from being contaminated by impurities coming from the walls, and to exhaust – in a power plant - also the helium which is formed as ash in the fusion reactions.

In Wendelstein 7-AS the use of a divertor resulted in the formation of a plasma with good confinement properties, at densities considerable in excess of those usually achieved in magnetic confinement devices of comparable magnetic field strength and size. This offers very good prospects for the operation of the successor experiment Wendelstein 7-X, presently under construction in Greifswald.

As desired, the thermal insulation of the plasma – measured by the energy confinement time – was found to improve also with increasing density, while the confinement time for particles and in particular impurities decreased. Therefore impurities did not accumulate in the plasma core and full density control and quasi-stationary operation were possible.

The plasma edge of a stellarator splits into individual bulges without further intervention – in keeping with the symmetry of the magnetic field. These “islands” are lined up like a string of pearls around the cross-section of the plasma and the direct energy and particles to limited sections of the vessel wall. Protecting these areas with collector plates allows the impinging particles to be removed from the plasma together with impurities.

The physical details from the first series of divertor experiments in a Wendelstein stellarator are now to be clarified in further experiments. The information gained is particularly important for Wendelstein 7-X, the follow-up experiment now being built at the Greifswald Branch of IPP.

Lower Divertor Module of Wendelstein 7-AS

Tokamak and Stellarator at the Association EURATOM-IPP

IPP is at present the only institute in the world operating the two major types of device – the tokamak and the stellarator – parallel to one another. One of the crucial questions of equal concern to both types is the plasma purity attainable. Tokamaks were relieved of this problem in 1982 by the ASDEX device at IPP: a divertor directed the boundary layer of the plasma to specially equipped collector plates at the top and bottom of the plasma vessel, where the plasma particles were neutralized and pumped off together with impurities. This is also how the “ash” of the fusion process – the helium – is to be removed in a future power plant.

You would like to have more Information on IPP?

http://www.ipp.mpg.de/

PLASMA HEATING SYSTEMS

Gyrotron

Maser oscillator for generating high power microwaves in the electron cyclotron range of frequencies (28 - 200 GHz).

More Information on Gyrotrons:

http://crppwww.epfl.ch/crpp_gyro.htm

Gyrotron Performance Reaches new Record Values

RF power production in the Electron Cyclotron Resonance Frequency (ECRF) range is one of the key technologies needed for ITER and for future fusion power plants. Due to the ease of coupling power at these frequencies to the plasma, and the excellent control of the power deposition profiles, ECRF heating and current drive are also important instruments for physics investigations in experiments already in operation or construction.

The state of art of suitable RF sources (gyrotrons) has made a significant step forward with the first tests of the „Maquette" prototype tube, specified for Wendelstein 7-X, the new stellarator experiment at the Association EURATOM-IPP (Greifswald, Germany). Research institutes like Association EURATOM-FZK (Karlsruhe), -CRPP (Lausanne), -CEA (Cadarache), IPF Stuttgart and TED Vélizy developed "Maquette" as a joint collaboration project.

The maquette has a synthetic diamond window and a depressed collector to recover energy and enhance its efficiency. The tube has been designed and constructed for continuous wave (CW) operation. The $TE_{28,8}$ cavity mode is converted by an improved quasi-optical mode converter system to a Gaussian output beam.

In short pulse operation (a few milliseconds) an output power of 1.15 MW at a beam voltage of 84 kV, a beam current of 40 A and a depression voltage of 25 kV could be achieved. The output efficiency for this measurement is 49%. The Radio Frequency (RF) beam distribution was measured with an infrared camera and was found to be in very good accordance with theory.

Specifications of "Maquette"

- **pulse length**
  ≥ 1 s
- **frequency**
  140 GHz
- **output power**
  1 MW with a Gaussian content ≥ 90%
- **efficiency**
  > 45%

Maquette Gyrotron

Output power and efficiency measurements in long pulse operation for different pulse lengths

MW	%	s
0.47		180
0.64		140
0.86	39	40
1.0	50	10

Within two months, the pulse length was increased to 140 s at an RF output power of 0.64 MW. This pulse length means a world record energy content in one pulse (about 90 MJ). The output power was limited by arcing inside the RF absorber load.

A visual inspection of the absorber load showed some spots where arcing had occurred. After replacing the original rotating mirror of the RF absorber load by a conical, non- rotating one, the power could be increased to 0.86 MW with a pulse length of 40 s and to about 1 MW for 10 s with an efficiency of about 50%. The pulse length was not limited by the tube itself, but due to lack of experimental time farther increases to the pulse lengths were not attempted.

For more Information about Wendelstein 7-X

http://www.ipp.mpg.de/eng/pr/forschung/w7x/pr_for_w7x.html

FUSION AND THE PUBLIC

EFDA at the SUSTAIN 2001 Exhibition

The 2001 edition of the SUSTAIN exhibition was held in the Europa Hall in Amsterdam from May 8 to 10, 2001. This was the third year of the exhibition, which is dedicated to all kinds of sustainable energies, such as hydropower, biomass, solar, wind, tidal, geothermal, etc.

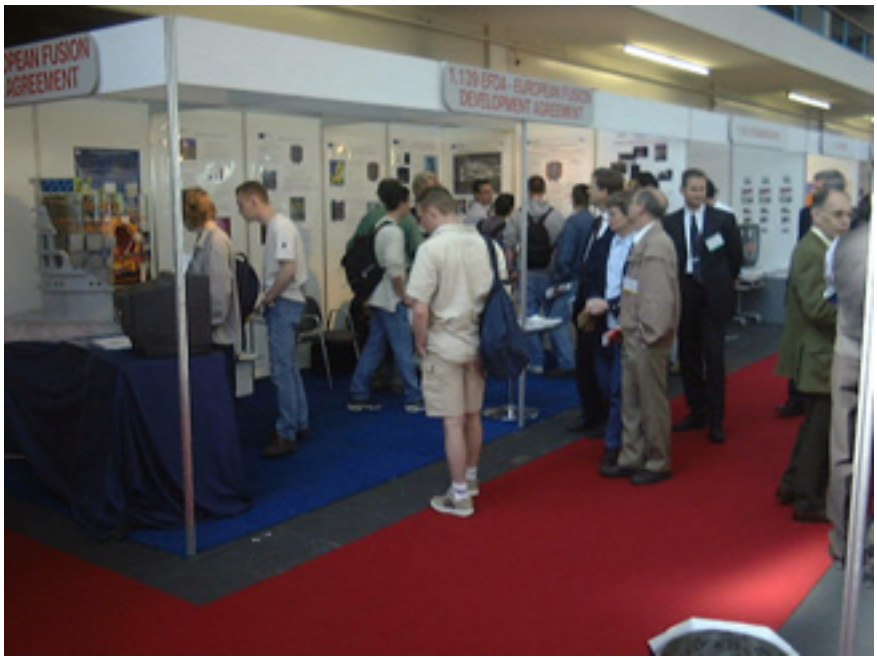
The EFDA stand, organized with the support of the Association EURATOM-FOM (Netherlands) presented the ITER Model, together with brochures, posters, films and CD-ROMS, featuring ITER and JET in particular as well as Fusion in general. "The Starmakers" - a film explaining the operation of a fusion reactor - was one of the most interesting objects for our visitors.

The visitors of the exhibition were mostly from the energy business, but there were also students, teachers and members of the general public. The impression was that 80% of the visitors knew about fusion and no explanation of the process was necessary. Several teachers were interested in including fusion into the energy panorama, which they present, during the year, to their students.

A scanning device for the visitors' badges allowed us to register the data of approx. 100 persons, representing roughly 40% of the ones who asked our stand personnel questions.

Several times visitors asked questions about the future cost of fusion energy, as well as questions about how much of the future share of the world's energy demand could be covered by fusion. One visitor asked why oil companies were not financing fusion. In his opinion this would help provide the world with a future alternative in a timely fashion.

Our experience has to be considered in a very positive way. We found wide support for our approach to consider fusion, which can cover base load energy demand, as complementary to other renewables. The opinions of the visitors towards fusion was positive as well and full of trust in our work to provide a future energy source.



EFDA Stand at the Sustain 2001 Exhibition

Since its debut in 1997 SUSTAIN, the bi-annual World Sustainable Energy Exhibition & Conference has become the major event to focus on the sustainable energy market. The number of visitors in 2001 was almost 7000, approx. 10% more than in 1999. The 2001 edition was attended by visitors from over 80 countries. Almost twice as many journalists visited SUSTAIN 2001 compared with the previous edition.

Some of the Visitors, of the EFDA Stand:

- DeWind
- US DoE
- Bodycote
- McKinsey
- Maharishi Solar
- Novem
- NUON

QUESTIONS ON FUSION

In this section we will answer questions posed to us via our website (www.efda.org). In this first issue we respond to the three questions most frequently asked by the visitors of the EFDA stand at the SUSTAIN 2001

Questions:

1. When will Fusion Power Plants be able to contribute to energy supply?
2. Will Fusion Power Plants reduce global warming, acid rain and air pollution?
3. Can fusion power plants keep us independent of international energy imports?

Answers:

1. The next step after ITER will be a demonstration power plant, which will be self-sufficient in its fuel cycle and deliver electrical power to the grid. It will differ only slightly from the first generation of commercial power plants, the construction of which could be started within the first half of this century. According to studies carried out to assess the feasible impact of fusion on the future energy market, fusion could win a considerable share in the electricity market by the year 2100.
2. Fusion energy is generated through nuclear reactions, which do not involve any kind of chemical combustion. Therefore no greenhouse gases are generated as a result of these reactions.
3. The fusion reaction between deuterium and tritium is the easiest to achieve. There are about 35 grams of deuterium in every cubic metre of water. Tritium can be produced artificially from lithium, which is one of the most abundant light metals in the earth's crust. Therefore deuterium and lithium reserves are evenly distributed on earth and are not property of a limited number of countries as it is the case for fossil fuels. This is a very important issue for areas such as the European Union, which, according to the published sources, has currently a 50% dependence on external energy imports and is going to increase it to 70% until 2020 if no countermeasures are adopted. These values explain why two of the largest world economies such as the European Union and Japan, which largely depend on external energy supplies, are carrying out the largest effort in fusion research.

CONFERENCE GUIDE

Date	Conference	Website
21 – 25 January 2002	19th SOFE, Atlantic City, NJ (USA)	
7 – 12 April 2002	6th International Symposium on Fusion Nuclear Technology, San Diego (USA)	http://cer.ucsd.edu/isfnt.html
27 – 31 May 2002	15th International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI-15), Gifu (Japan)	
17 – 21 June 2002	29th EPS Conference on Plasma Physics and Controlled Fusion, Montreux (CH)	http://crppwww.epfl.ch/eps2002
9 – 13 September 2002	22nd Symposium on Fusion Technology (SOFT), Helsinki (SF)	http://vtt.fi/val/soft2002
14 – 19 October 2002	19th IAEA Fusion Energy Conference, Lyon (F)	

For more information:

www.efda.org
www.jet.efda.org
www.iter.org

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