



# **Fusion como fuente de energía futura y su impacto presente en España**

**Carlos Alejaldre**

**Director General**

**CIEMAT**

**Former Deputy Director General ITER**

**ENERMADRID**  
Nuevas Tecnologías Energéticas  
8 Octubre 2020

# Consumo Energético

Consumo Mundial de Energía  
90's

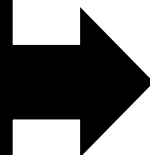
x 3? =

Consumo Energético Mundial Siglo XXI

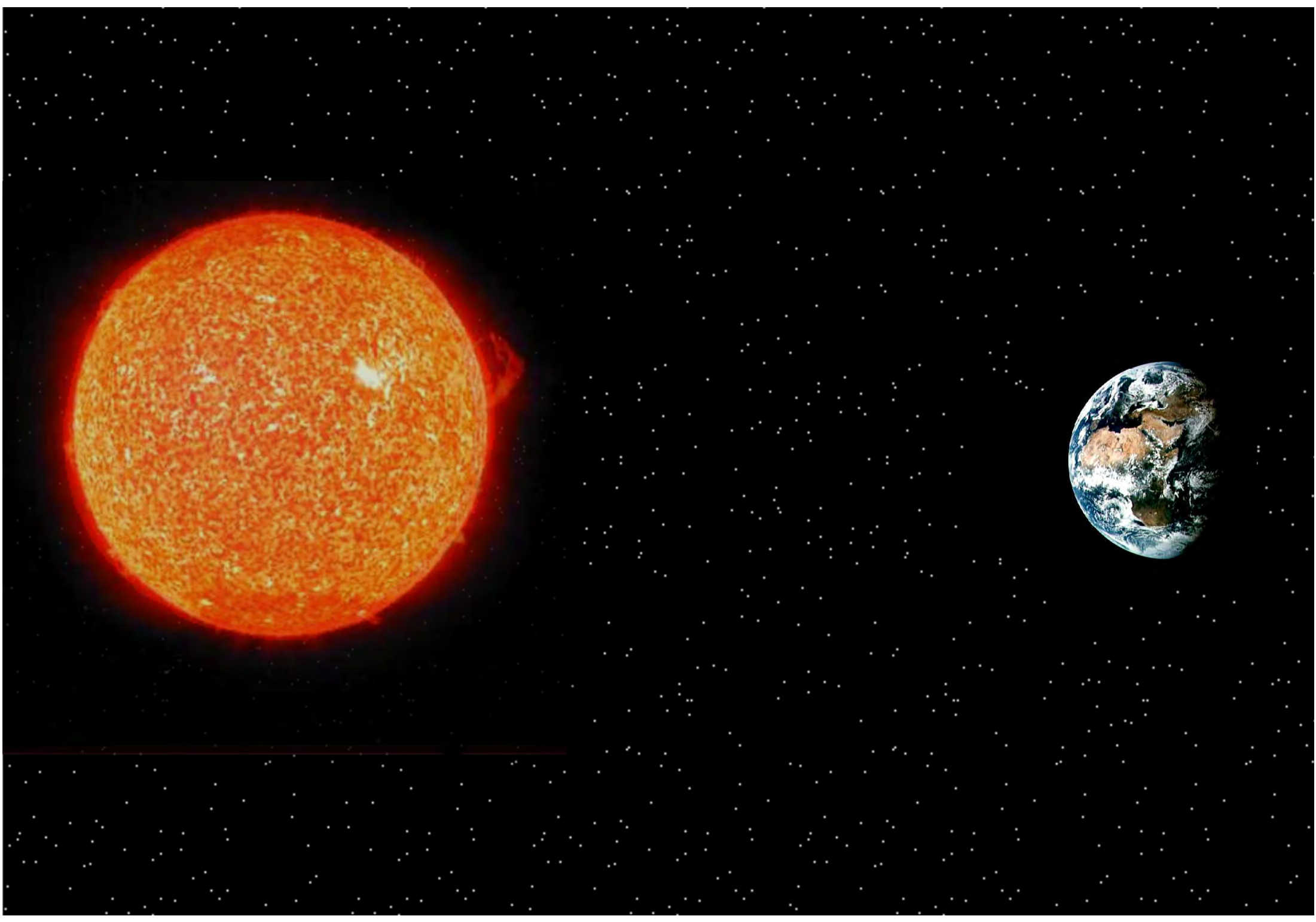
Petroleo	43 (32)%
Carbón	22 (30)%
Gas	20 (24)%
Nuclear	8 (4)%
Hydro	5 (7)%
Otro	2 (3)%

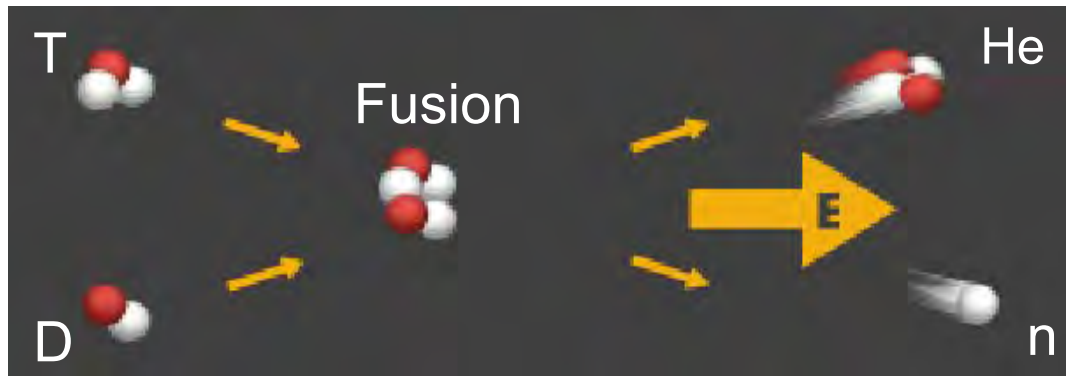
BP 2017 ENERGY OUTLOOK

Nuevo Cóctel Energético



Disponibilidad de recursos  
Consecuencias medioambientales  
Seguridad de suministro





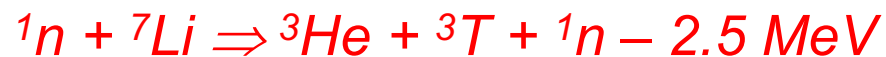
+ 20% de Energía (3.5 MeV)

+ 80% de Energía (14.1 MeV)

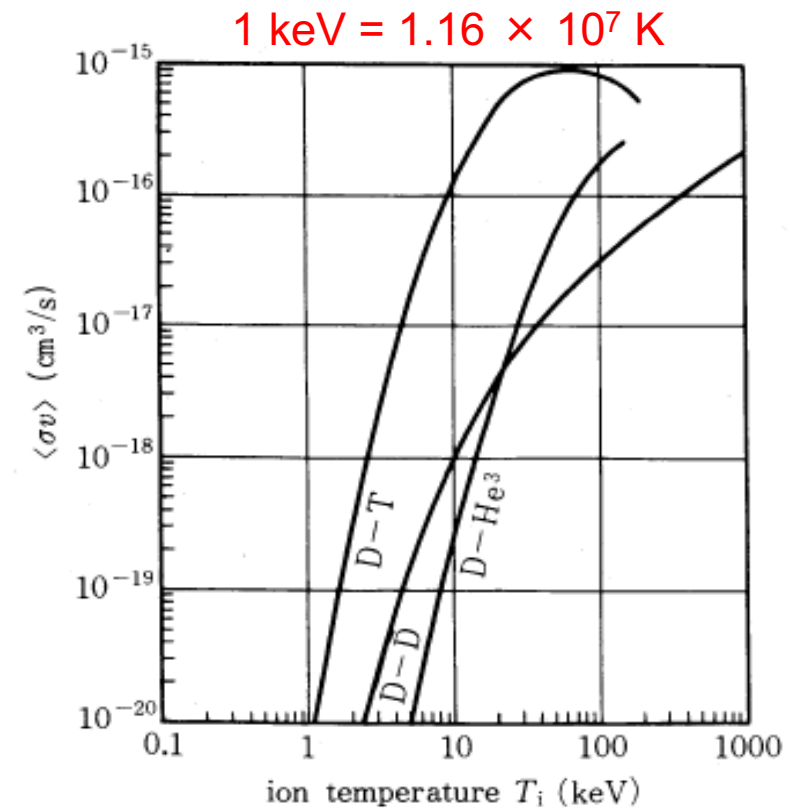
- La reacción de fusión más sencilla de conseguir en condiciones terrestres:



- Otras dos reacciones importantes para la fusión DT son:



- Estas reacciones permitirán a un reactor de fusión **generar tritio**



# Combustible Fusion

La materia prima de una planta de fusion es agua y litio\*



≈



45 litros de agua

+



Batería ordenador

Litio en una bateria de un ordenador portàtil + media bañera de agua (-> **un dedal de agua pesada**) puede producir 200,000 kW-hora

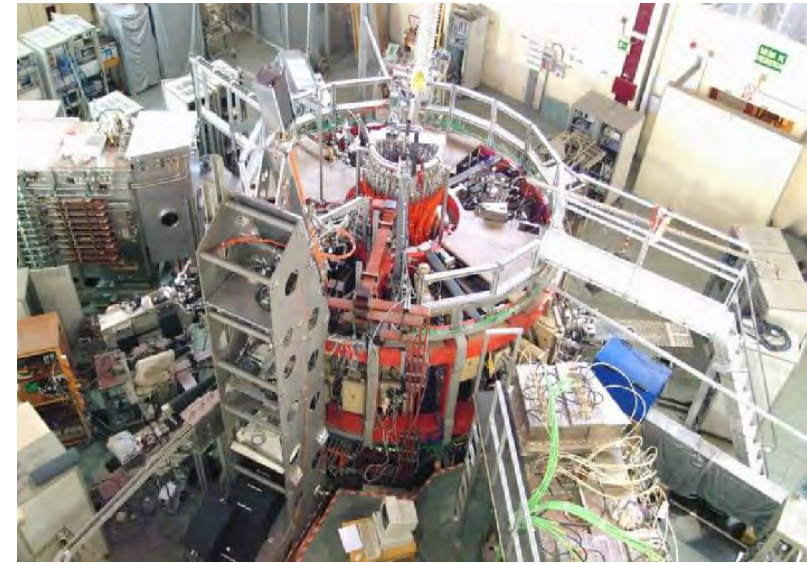
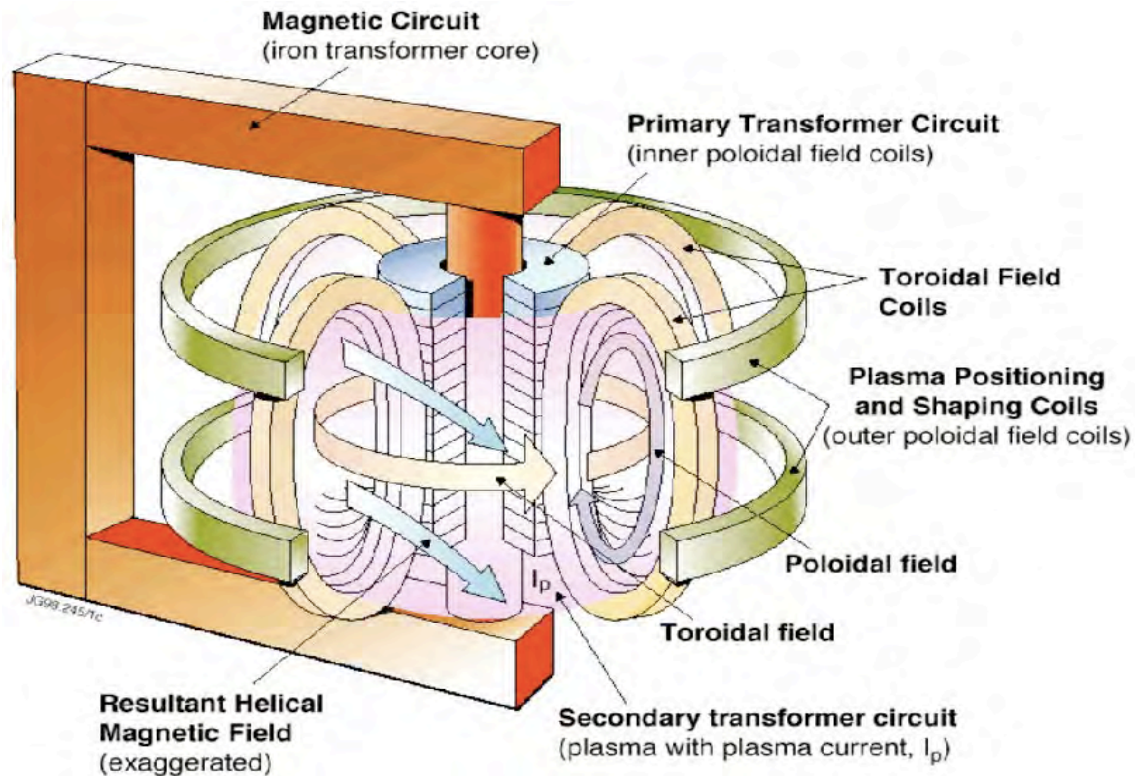
≈ consumo promedio de un español durante 45 años

\* **Deuterio/hydrogeno** = 1/6700

+ **tritio de:** *neutron (de fusion) + litio* → *tritio + helio*

# Las Botellas: Tokamak y Stellarator

"тороидальная камера в магнитных катушках"  
(*toroidal'naya kamera v magnitnykh katushkakh*) —  
toroidal chamber in magnetic coils (Tokamak).



TJ-II  
CIEMAT



LHD  
Japón

"All the News  
That's Fit to Print"

# The New York Times

Late Edition

Weather: Rain likely today, strong easterly winds; rain ending late tonight. Partly cloudy and warmer tomorrow. Temperatures: today 43-47, tonight 40-45; yesterday 38-62. Details, page C30.

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60 cents beyond 75 miles from New York City, except on Long Island.

30 CENTS

## Text of the Joint U.S.-Soviet Statement: 'Greater Understanding Achieved'

Special to The New York Times

**EVA, Nov. 21** — Following is the text of the joint Soviet-American statement at the end of the summit meeting today, as made public by the Moscow side:

The summit was held on the basis of a mutual agreement, the President of the United States, Ronald Reagan, and the General Secretary of the Central Committee of the Communist Party of the Soviet Union, Mikhail Gorbachev, met in Geneva on Nov. 21. Attending the meeting on the Soviet side were Secretary of State P. Shultz; chief of staff, Donald Regan; Assistant to the President, Robert C. McFarlane; Ambassador to the U.S.S.R., Arthur A. Hartness; special adviser to the President, Robert C. McFarlane; Assistant Secretary of State for Arms Control and International Security Affairs, Paul H. Nitze; Assistant Secretary of State for European Affairs, L. Ridgway; Special Assistant to the President for National Security Affairs, Jack F. Matlock. On the U.S. side were members of the Politburo of the Central Committee of the C.P.S.U., including Foreign Affairs Eduard Shevardnadze; First Deputy Foreign Minister Georgi M. Korniyenko; Ambassador to the United States, F. Dobrynin; head of the Department of Propaganda of the Central Committee of the C.P.S.U., Aleksey Yakovlev; head of the Department of International Information of the Central Committee of the C.P.S.U., Leonid M. Zamyatin; and the General Secretary of the Central Committee of the C.P.S.U., Andrei M. Aleksandrov. The summit included comprehensive discussions on the basic questions of U.S.-Soviet relations and the current international situation. The meetings were productive and useful. Serious differences were discussed on a number of critical issues, including the different approaches to their systems and approaches to international issues, and a deeper understanding of each other was achieved by the two sides. They agreed about the need to improve U.S.-Soviet relations and the international situation as a whole.

In this connection the two sides have confirmed the importance of an ongoing dialogue, reflecting their strong desire to seek common ground on existing problems.

They agreed to meet again in the nearest future. The General Secretary accepted an invitation by the President of the United States to visit the United States of America, and the President of the United States accepted an invitation by the General Secretary of the Central Committee of the C.P.S.U. to visit the Soviet Union. Arrangements for the timing of the visits will be agreed upon through diplomatic channels.

In their meetings, agreement was reached on a number of specific issues. Areas of agreement are registered on the following pages.

### Security

The sides, having discussed key security issues, and conscious of the special responsibility of the USSR and the U.S. for maintaining peace, have agreed that a nuclear war cannot be won and must never be fought. Recognizing that any conflict between the U.S.S.R. and the U.S. could have catastrophic consequences, they emphasized the importance of preventing any war between them, whether nuclear or conventional. They will not seek to achieve military superiority.

### Nuclear and Space Talks

The President and the General Secretary discussed the negotiations on nuclear and space arms.

They agreed to accelerate the work at these negotiations, with a view to accomplishing the tasks set down in the Joint U.S.-Soviet Agreement of Jan. 8, 1985, namely to prevent an arms race in space and to terminate it on earth, to limit and reduce nuclear arms and enhance strategic stability.

Noting the proposals recently tabled by the U.S. and the Soviet Union, they called for early progress, in particular in areas where there is common ground, including the princi-

ple of 50 percent reductions in the nuclear arms of the U.S. and the U.S.S.R. appropriately applied, as well as the idea of an interim I.N.F. agreement.

During the negotiation of these agreements, effective measures for verification of compliance with obligations assumed will be agreed upon.

### Risk Reduction Centers

The sides agreed to study the question at the expert level of centers to reduce nuclear risk taking into account the issues and developments in the Geneva negotiations. They expressed satisfaction in such recent steps in this direction as the modernization of the Soviet-U.S. hot line.

### Nuclear Nonproliferation

General Secretary Gorbachev and President Reagan reaffirmed their commitment of the U.S.S.R. and the U.S. to the Treaty on the Nonproliferation of Nuclear Weapons and their interest in strengthening together with other countries the nonproliferation regime, and in further enhancing the effectiveness of the treaty, in particular by enlarging its membership.

The U.S.S.R. and the U.S. reaffirmed their commitment, assumed by them under the Treaty on the Nonproliferation of Nuclear Weapons, to pursue negotiations in good faith on matters of nuclear arms limitation and disarmament in accordance with Article VI of the treaty.

The two sides plan to continue to promote the strengthening of the International Atomic Energy Agency and to support the activities of the Agency in implementing safeguards as well as in promoting the peaceful uses of nuclear energy.

They view positively the practice of regular Soviet-U.S. consultations on nonproliferation of nuclear weapons which have been businesslike and constructive, and express their intention to continue this practice in the future.

### Chemical Weapons

In the context of discussing security problems, the two sides re-

affirmed that they are in favor of a general and complete prohibition of chemical weapons and the destruction of existing stockpiles of such weapons. They agreed to accelerate efforts to conclude an effective and verifiable international convention on this matter.

The two sides agreed to intensify bilateral discussions on the level of experts on all aspects of such a chemical weapons ban, including the question of verification. They agreed to initiate a dialogue on preventing the proliferation of chemical weapons.

ministries and departments in such fields as agriculture, housing and protection of the environment have been useful.

Recognizing that exchanges of views on regional issues on the expert level have proven useful, they agreed to continue such exchanges on a regular basis.

The sides intend to expand the programs of bilateral cultural, educational and scientific-technical exchanges, and also to develop trade and economic ties. The President of the United States and the General

Secretary of the Soviet Union — a global task — through joint research and practical measures. In accordance with the existing U.S.-Soviet agreement in this area, consultations will be held next year in Moscow and Washington on specific programs of cooperation.

### Exchange Initiatives

The two leaders agreed on the utility of broadening exchanges and contacts including some of their new forms in a number of scientific

## Fusion Research

The two leaders emphasized the potential importance of the work aimed at utilizing controlled thermonuclear fusion for peaceful purposes and, in this connection, advocated the widest practicable development of international cooperation in obtaining this source of energy, which is essentially inexhaustible, for the benefit for all mankind.

# Collaboration is our greatest asset



Ceremony ITER Agreement Signature, Elysee Palace, 21 November 2006

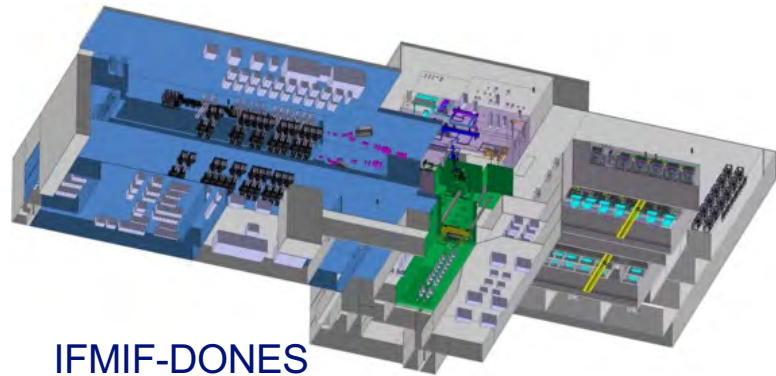


# Tokamak Complex

An aerial photograph of the Tokamak Complex under construction. The central focus is a large, circular structure, likely the tokamak itself, surrounded by a complex network of steel scaffolding and construction equipment. To the right, several large, rectangular industrial buildings are visible, some with flat roofs and others with more complex structures. The site is surrounded by a mix of green fields and wooded areas under a blue sky with scattered clouds. A tall crane is visible on the left side of the image.

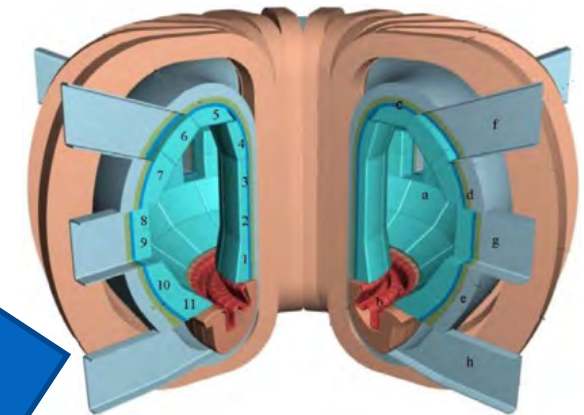
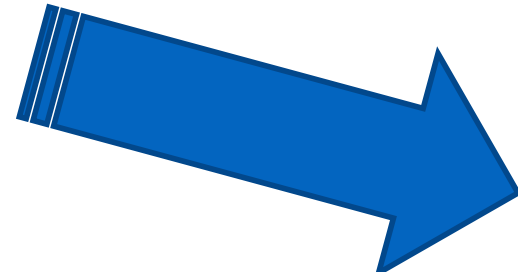
Resting on 493 seismic pads, the 440 000-ton Tokamak Complex comprises 7 levels (2 underground).

# ROADMAP TO NUCLEAR FUSION ENERGY



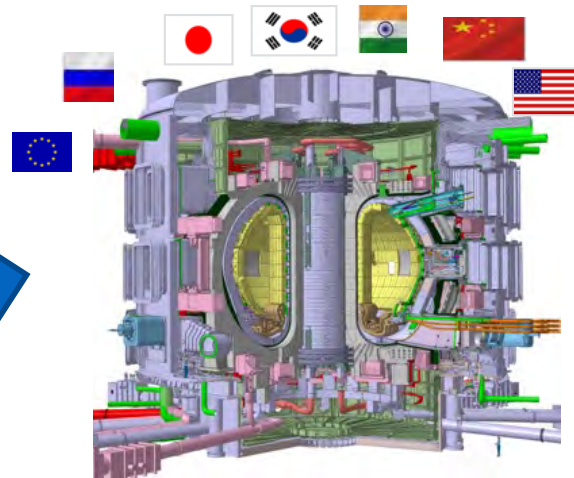
IFMIF-DONES

D<sup>+</sup> beam, 40 MeV, 125 mA on a Li target



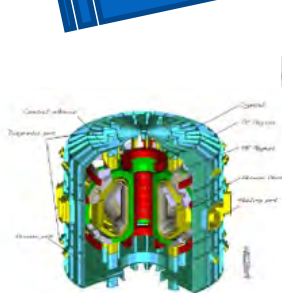
DEMO  $\geq 500 \text{ MW}_{el}$

1-2 hours



ITER –  $500 \text{ MW}_{th}$

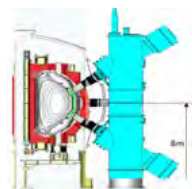
300– 500 secs



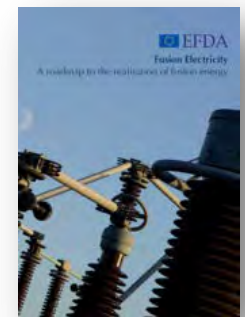
K-STAR



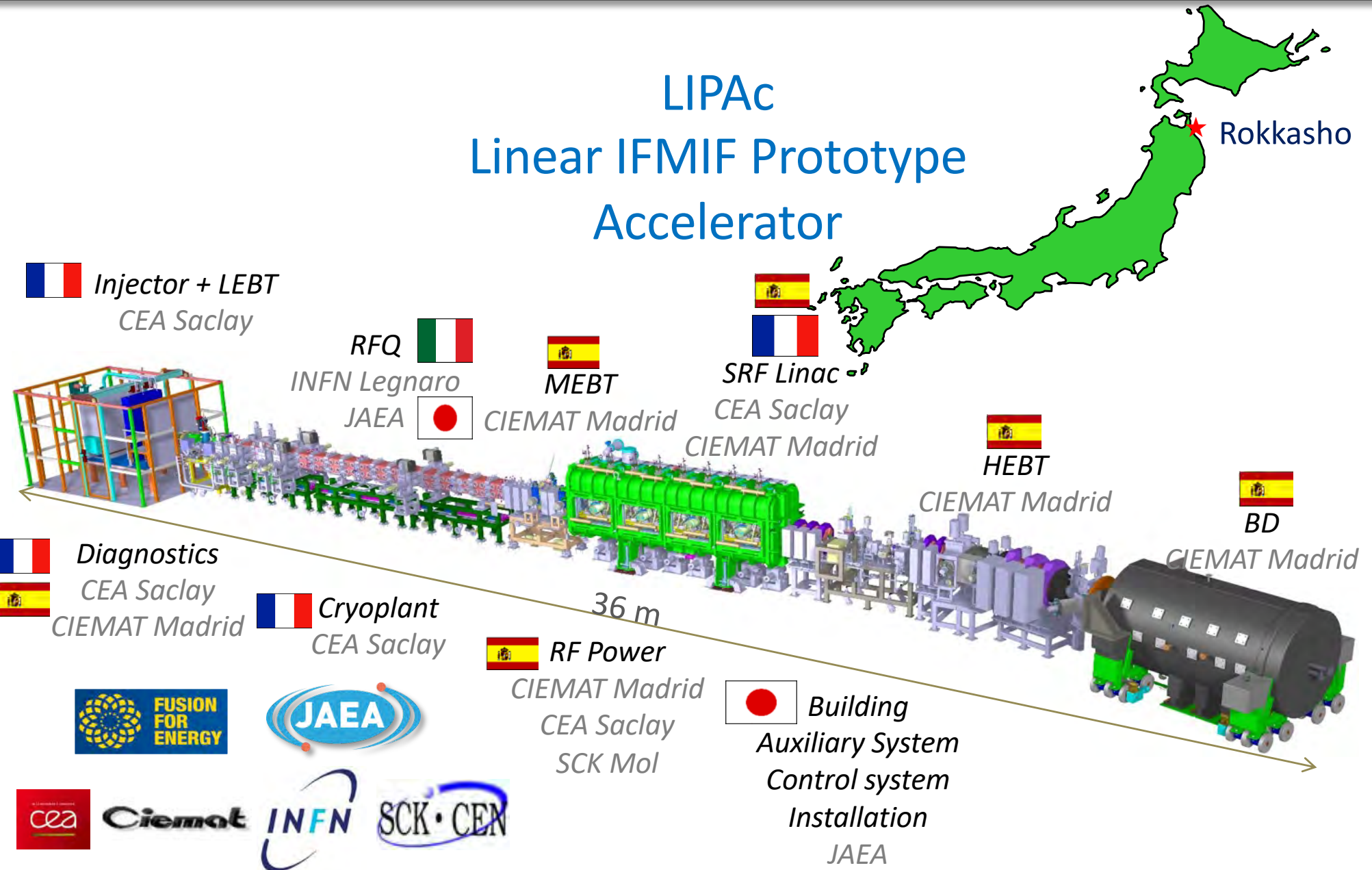
JET



JT-SU



# LIPAc Linear IFMIF Prototype Accelerator



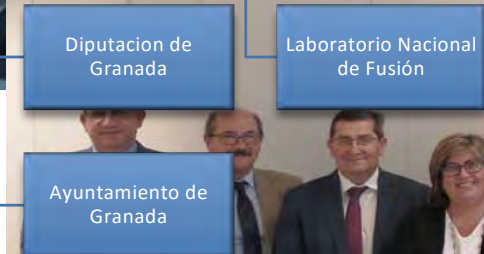
# Comisión para la Implementación de IFMIF-DONES en España



Presidente  
 Rafael Rodrigo, Secretario General de Investigación

Vicepresidente  
 Rogelio Velasco, Consejero de Economía, Conocimiento, Empresas y Universidad

Carlos Alejandre  
 DG CIEMAT



# DONES SITE LOCATION

It is located in the Granada province (Andalusia region – southern Spain), 18 km southwest from Granada city in the Granada Metropolitan park (Escúzar ).



ESFRI Roadmap | www.esfri.eu

Foreword | ESFRI Roadmap 2018

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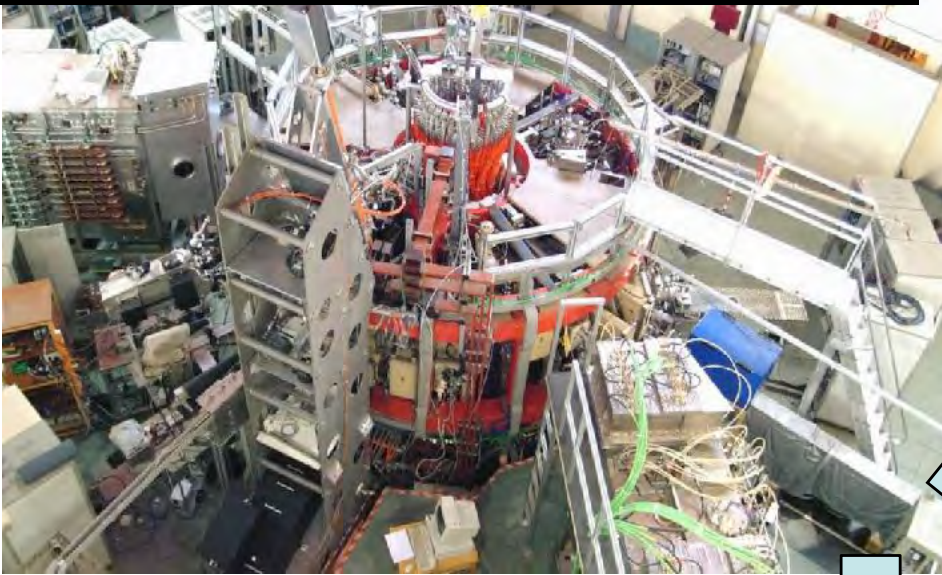
Part 1  
**STRATEGY REPORT**

Part 2  
**LANDSCAPE ANALYSIS**

Part 3  
**PROJECTS & LANDMARKS**

# Fusión en España: impacto

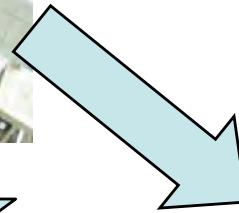
## INSTALACION SINGULAR TJ-II



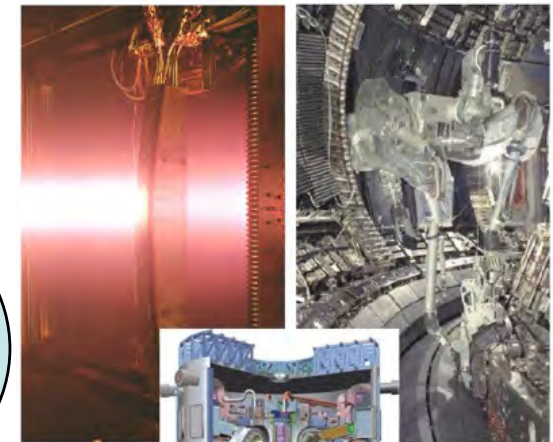
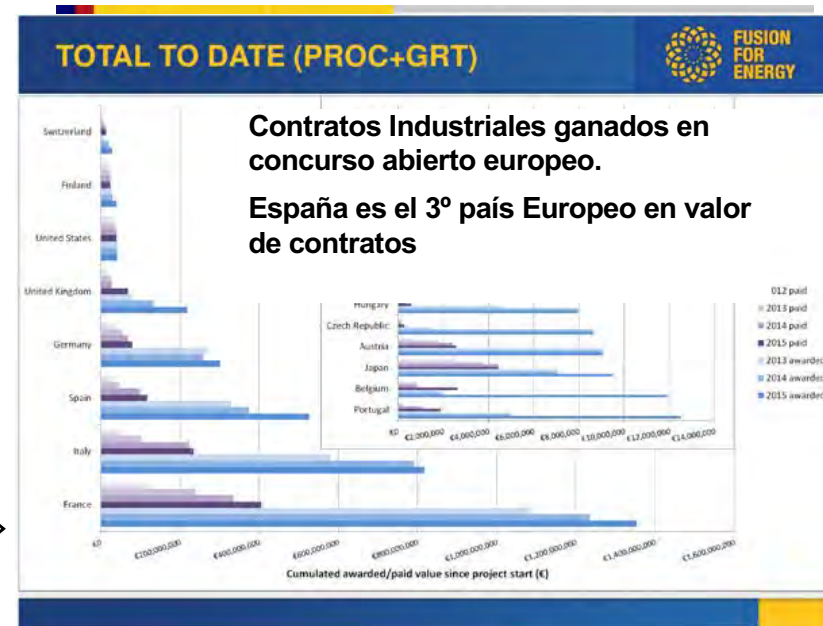
Implicar al sistema nacional de I+D

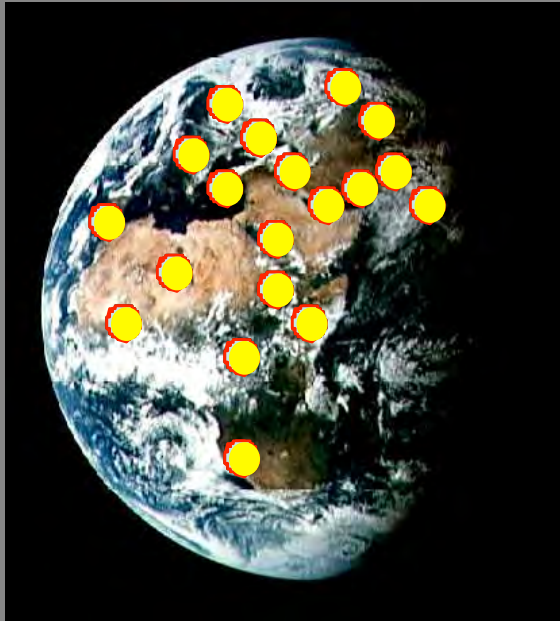


Implicar a la Industria



**INDUSTRIA**  
Apoyo Tecnológico en Fusión





**No hay una solución sencilla, ni probablemente única al problema energético de la Humanidad. Intensificar la investigación en Energía es una necesidad.**

**Viabilidad científica de la fusión ha sido demostrada (16 MW en JET).**

**El Laboratorio mundial ITER, la demostración científica y tecnológica, se está instalando en Europa (Cadarache). Barcelona acoge la Agencia Europea del proyecto.**

**IFMIF-DONES es imprescindible para conseguir construir las futuras plantas de fusión.**

**España es parte importante de la estrategia Europea en Fusión y el Programa de Fusión buen ejemplo que un cambio en el modelo productivo es posible.**

**Fusión nuclear es una realidad y puede ser la fuente de energía inagotable, barata y medioambientalmente aceptable del Futuro**