# Esperienza di lavoro nella Commissione Europea,
# Il progetto ITER,
# Opportunità per i giovani

**Roma Univ. I,**

**7th Maggio 2019**

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**Policy Officer CE**

**Dir ENER D4 Bruxelles**

# Layout

1. "Back to University" Work experience, actual position in the EU Commission

1. ITER project

2. Young people oppurtunities

European Commission

# Briefly my experience / 1

- Crisi petrolio 73. Problema energia → Univ. Fisica Nucleare
- Universita' fine anni '70 prima meta' anni '80

Breve esperienza iniziale
- Insegnante matematica in un liceo linguistico
- Alitalia informatica

15 anni
- Centro Ricerche ENEA di Frascati sulla Fusione
- Numerose esperienze e collaborazioni internazionali: CEA, KIT, ITER, NEA DB

# Briefly my experience / 2

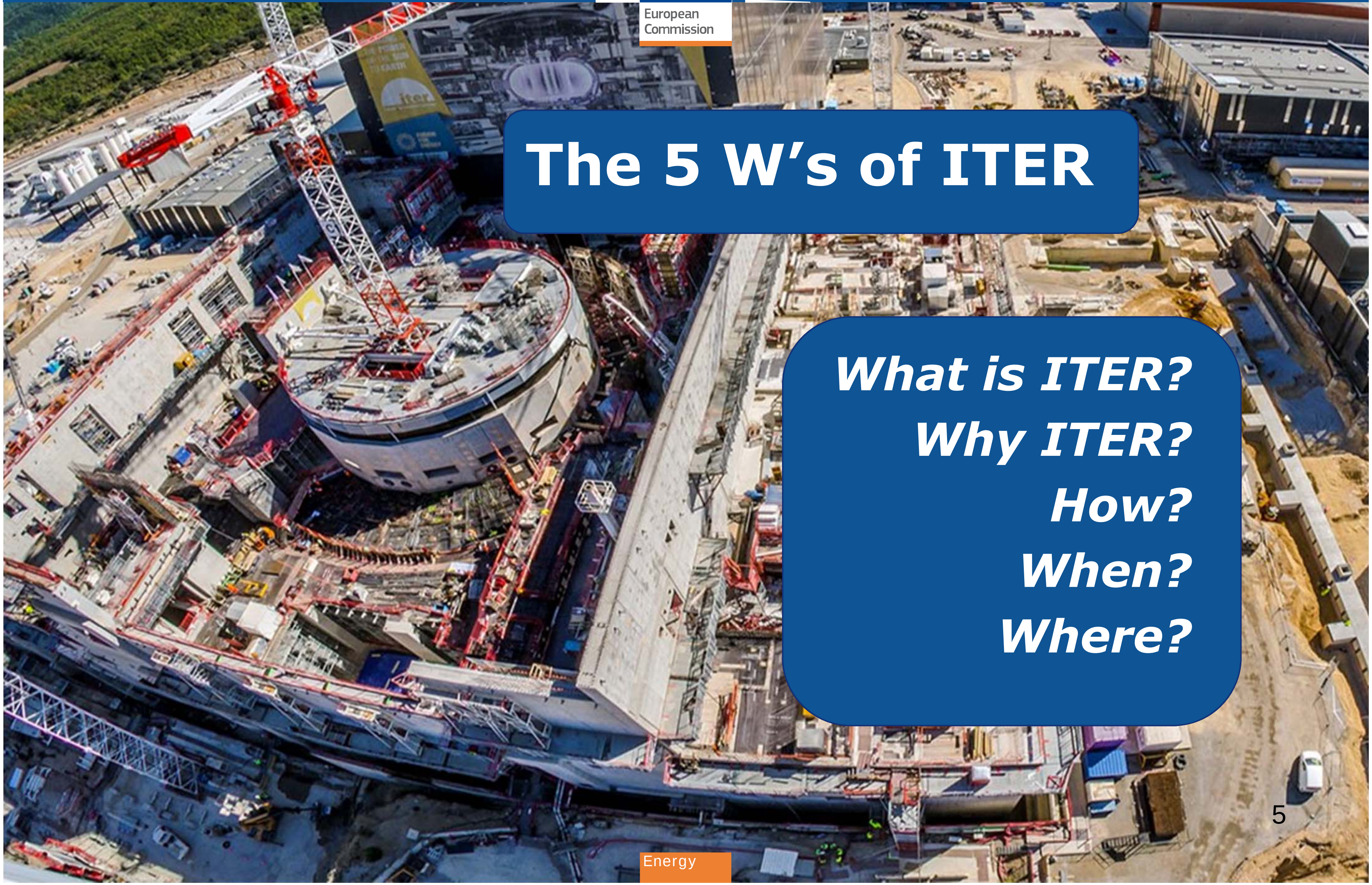
3 anni

- OECD/IAEA a Parigi

Ora

- Commissione Europea: sede a Bruxelles Belgio
- DG ENER Energia
- Unita' D4 progetto ITER
- "Policy Officer" con background scientifico

# The 5 W's of ITER



***What is ITER?***

***Why ITER?***

***How?***

***When?***

***Where?***

# ITER Objectives

# The Physics Context

*What is Fusion?*

- *Nuclear fusion is the reaction that powers the Sun and other stars*

- *Hydrogen nuclei fuse together, releasing energy*

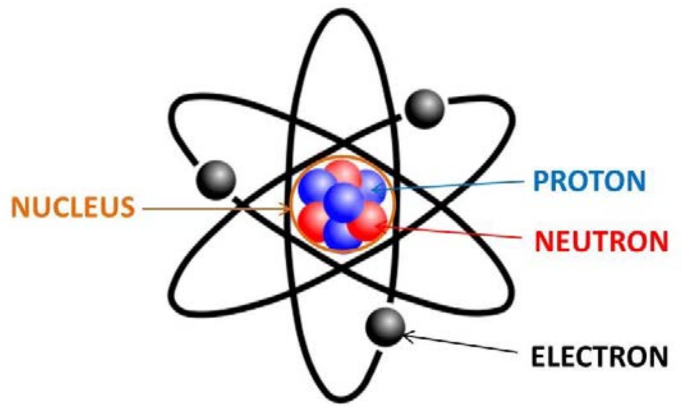
- *Fusion occurs inside a* ***plasma****. Plasma is the fourth state of matter – stars, lightning and neon lights are examples of plasma in daily life*

- *Creating and sustaining fusion inside a plasma and harvesting the energy released is a promising new form of energy*

# How does fusion happen?

In the nucleus of an atom, protons and neutrons (nucleons) are bound together by the **strong nuclear force**

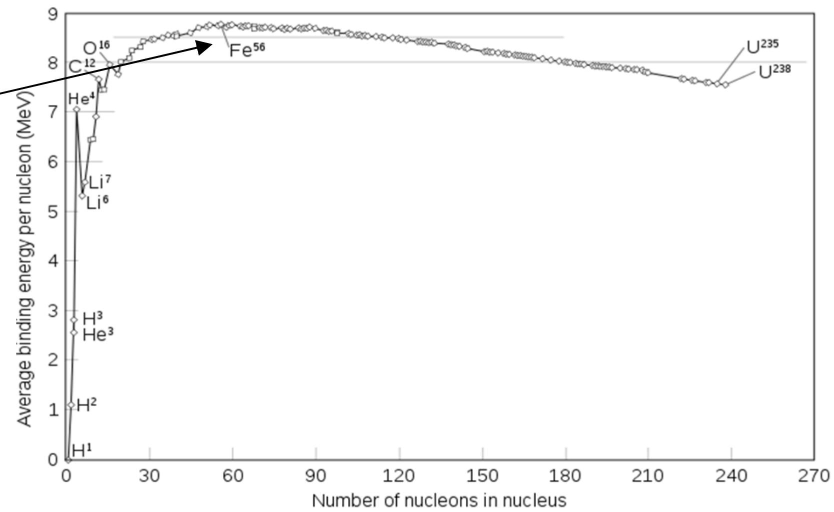
*The mass of a nucleus is always less than the total of the masses of its nucleons; the difference is called the* ***binding energy*** *of the nucleus*



# Why does fusion release energy?

- The most tightly bound atoms are called the "iron group“

- If a nucleus approaches the iron group through either fusion or fission it will become more tightly bound, meaning its mass per nucleon decreases. This mass has to be accounted for – it can’t disappear

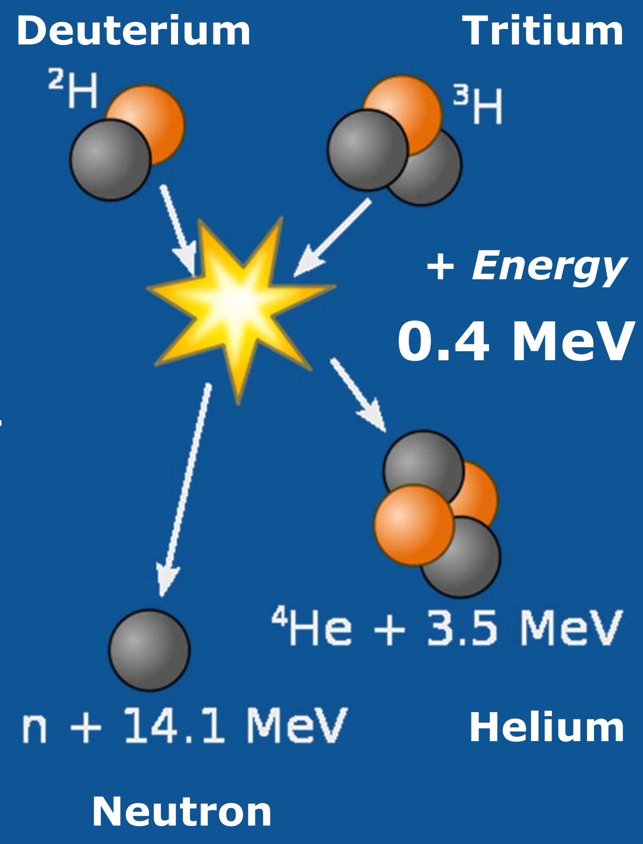



- Due to energy-mass equivalence ($E=mc^2$), this difference in mass is converted to energy – the kinetic energy of the products

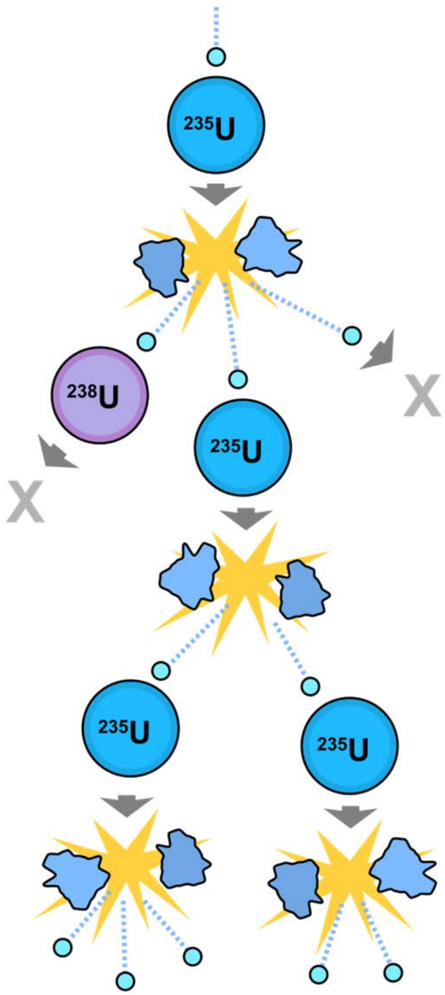
Graph source: Wikimedia Commons

# Fusion on Earth

- A plasma of Deuterium + Tritium (hydrogen isotopes) is heated to more than 150 million °C.
- The hot plasma is shaped and confined by
- strong magnetic fields.
- Helium nuclei sustain burning plasma.
- Neutrons transfer their energy to the Blanket .
- In a fusion power plant, conventional steam generator, turbine and alternator will transform the heat into electricity.



# Fusion Vs Fission



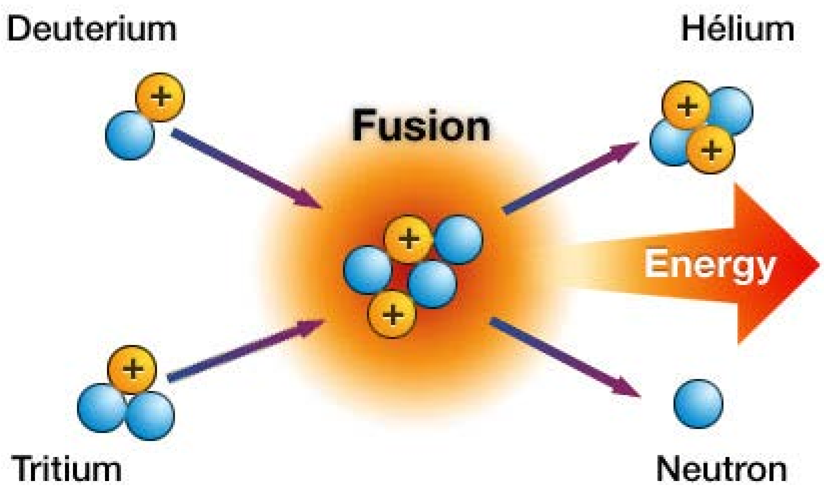

In the fission reaction, the nucleus splits into smaller nuclei.

Nuclear fission can be naturally a radioactive decay process or induced by neutrons. In the fission reactors a chain reaction is induced and controlled.

***Disadvantages:***

- *Uranium and plutonium resources are rare and not homogenously distributed*
- *Waste and higher radioactive materials as byproducts*

# Why Deuterium-Tritium Fusion?



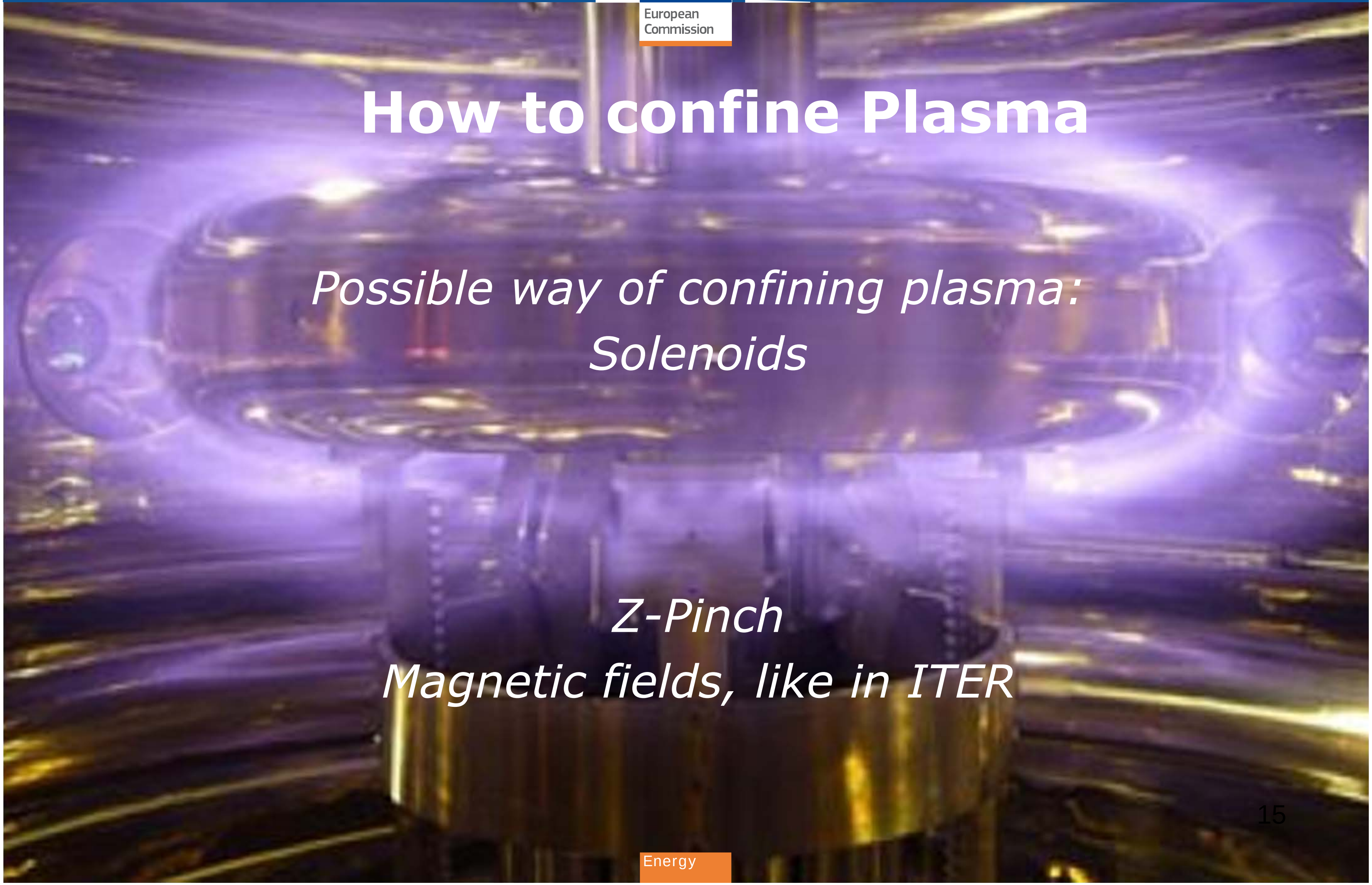

- Highest cross section area, meaning more probability of colliding with each other
- Helium (H4) is very stable
- Deuterium and Tritium are two **heavy** isotopes of Hydrogen, easy attainable
- The neutron carries over and transfer energy to the outer machine components

# How to Catch a Star

*T =150,000,000 °C*

European Commission

# How to confine Plasma



*Possible way of confining plasma:*

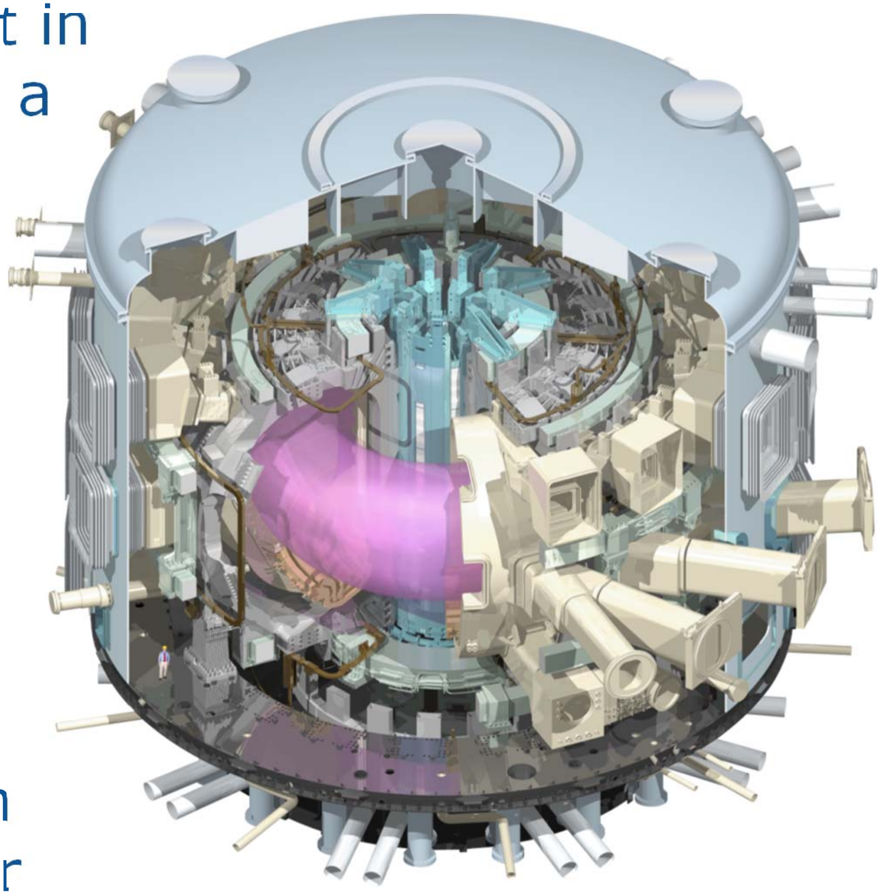
*Solenoids*

*Z-Pinch*

*Magnetic fields, like in ITER*

# How does it work a tokamak?

- Run a strong electrical current in the DT gas. You have created a plasma.
- Continue heating by electromagnetic waves.
- Inject high-energy neutral particles.
- By combining these different heating techniques, you reach the requested temperature for fusion reactions to occur.



# Deuterium – Tritium Supply

**Where do they come from?**

**How much do they cost?**

- Deuterium is found in seawater
- Tritium does not exist in nature, radioactive ($t_{1/2}$ 12.5 y) but it can be produced by Lithium6 ($^{6}Li$) + a neutron.
- Lithium is found in the earth crust and in seawater (again)

# Tritium Supply – CANDU Reactors

- Currently Tritium is produced by 3 countries in CANDU fission reactors (heavy water), mainly by Canada, South Korea

- CANDU heavy water reactors use non-enriched, natural uranium oxide as fuel and heavy water as a moderator

# The Historical Context

- **1930's:** scientists discovered that nuclear fusion was possible and that it was the energy source for the sun.

- **1940's:** researchers began to look for ways to initiate and control fusion reactions to produce useful energy on earth.

- **1950's:** administrators and scientists alike were convinced that controlled fusion research had no military applications.

*Therefore, it was declassified by the major participating nations, and cooperation in fusion began between the US and the USSR.*

# History of fusion energy Continued

- **December 8, 1953:** President Eisenhower delivered his "Atoms for Peace" speech before the United Nations General Assembly

- **1980's:** President Mitterrand, Prime Minister Thatcher, and General Secretary Gorbachev proposed to U.S. President Reagan an international project aimed at developing fusion energy for peaceful purposes, including Japan.

- **1985:** Secretary Gorbachev and President Reagan proposed an international effort to develop fusion energy…"as an inexhaustible source of energy for the benefit of mankind".

European Commission

# Early Timeline of Nuclear Fusion

1930s | 1950s | 1970s | 1990s | 2010s

**1930s**
Early experiments on nuclear physics

**1955**
First Atom for Peace meeting in Geneva

**1957**
EURATOM Treaty

**1973**
Design Work on JET begins

**1985**
Meeting Reagan/Gorbatchev

**2006**
ITER agreement signed

**2010**
ITER and beyond

# EURATOM Treaty

**Signed in 1957 in Rome**

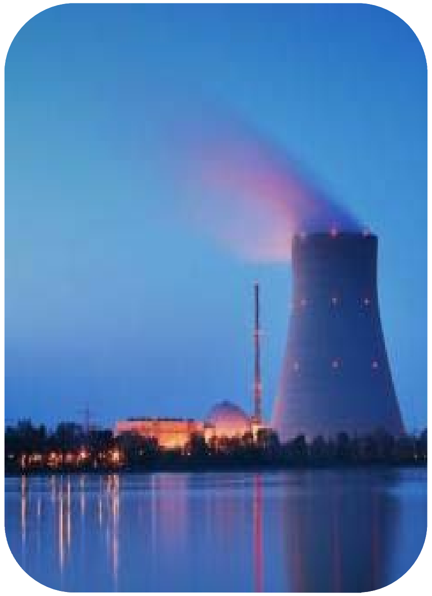
# EURATOM Treaty scope

Nuclear safety

Waste Management

Radiation Protection

Nuclear Safeguards



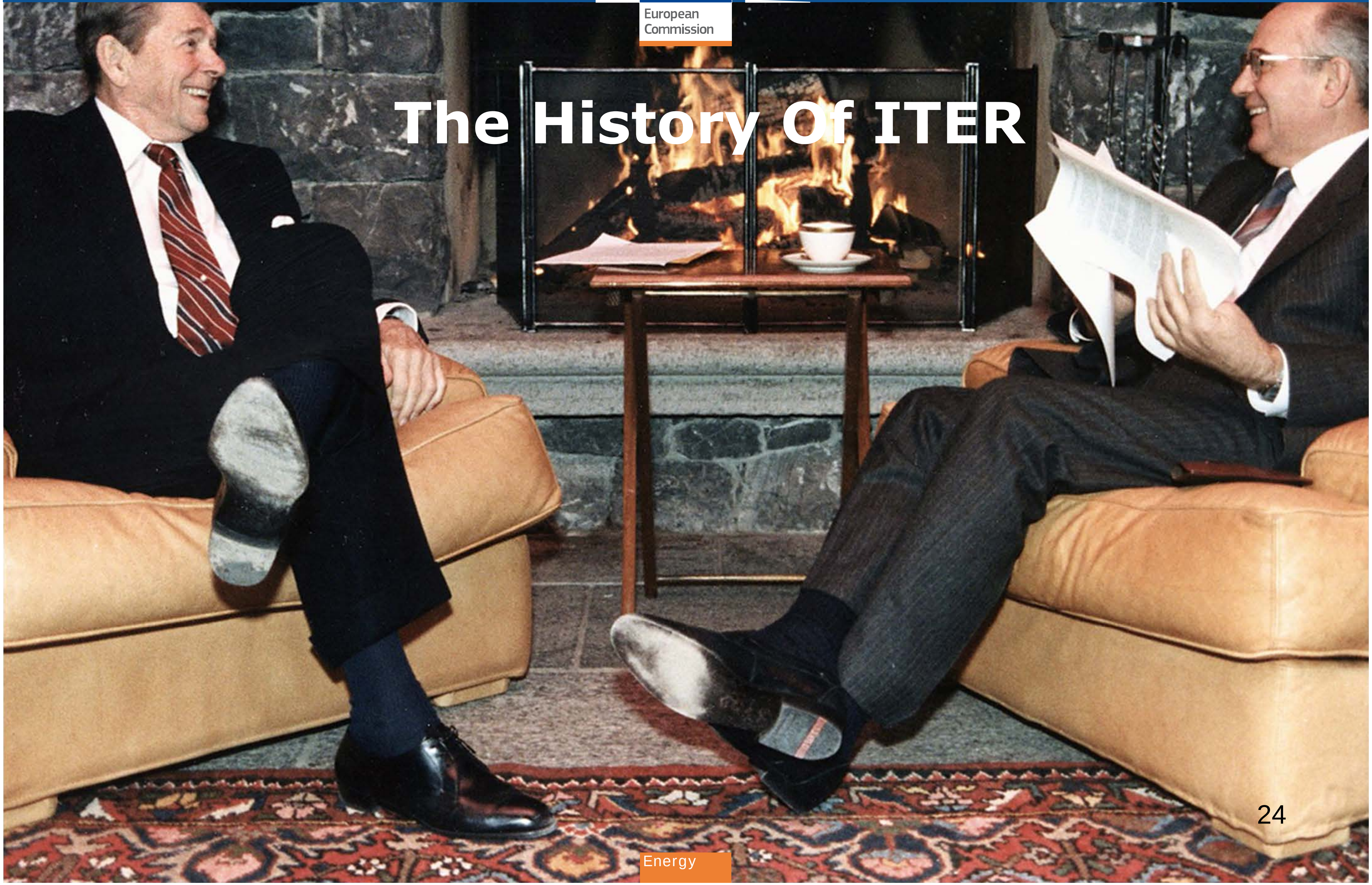
Emergency preparedness and response

Fuel supply policy (ESA)

International relations

Insurance and third-party liability

# The History Of ITER



## *1986-1987 - Discussions and Agreement*

*Establishment of an international collaboration among the USA, USSR, European Commission and Japan under the organization of the IAEA:* ***ITER - the International Thermonuclear Experimental Reactor***

## *1988-1991 - Conceptual Design Activities (CDA)*

*Start of common activities at Garching, Germany*
*Selection of machine parameters and objectives*

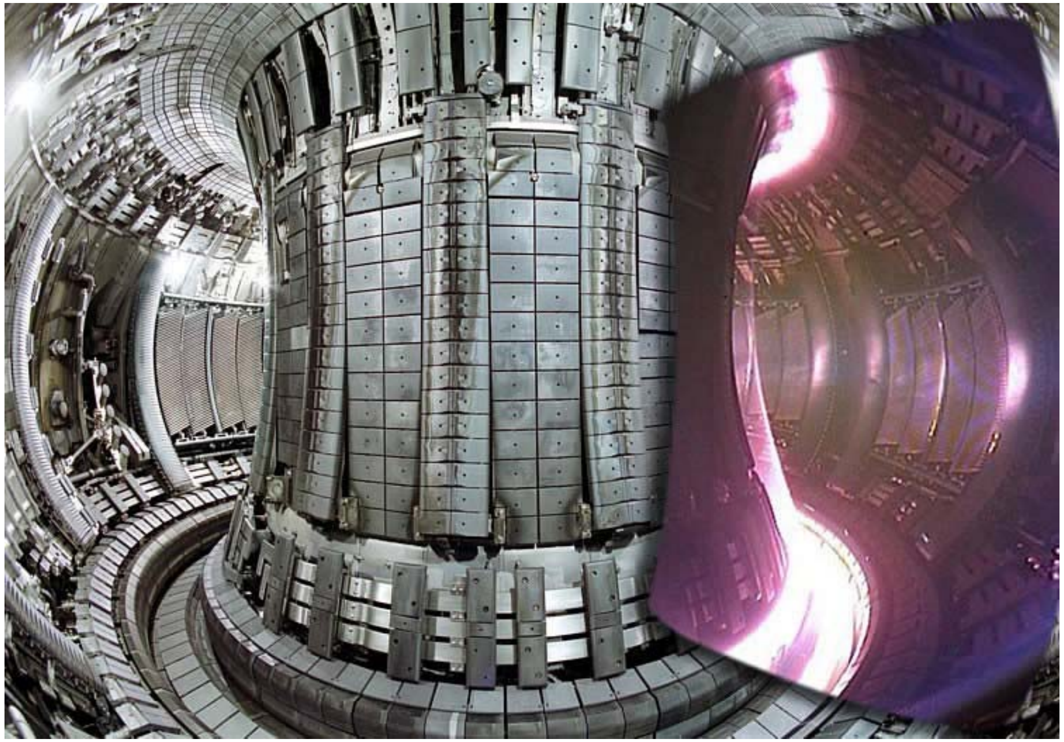
# The Road to ITER

**Joint European Torus (JET) (1984-)**

**Tora Supra Experiment (1988-2010)**

**WEST (2016 -)**

# Joint European Torus



The biggest currently operating tokamak that performs the same type of fusion as ITER is the Joint European Torus (JET) in the UK.

https://www.youtube.com/watch?v=YwdWyAcZr90

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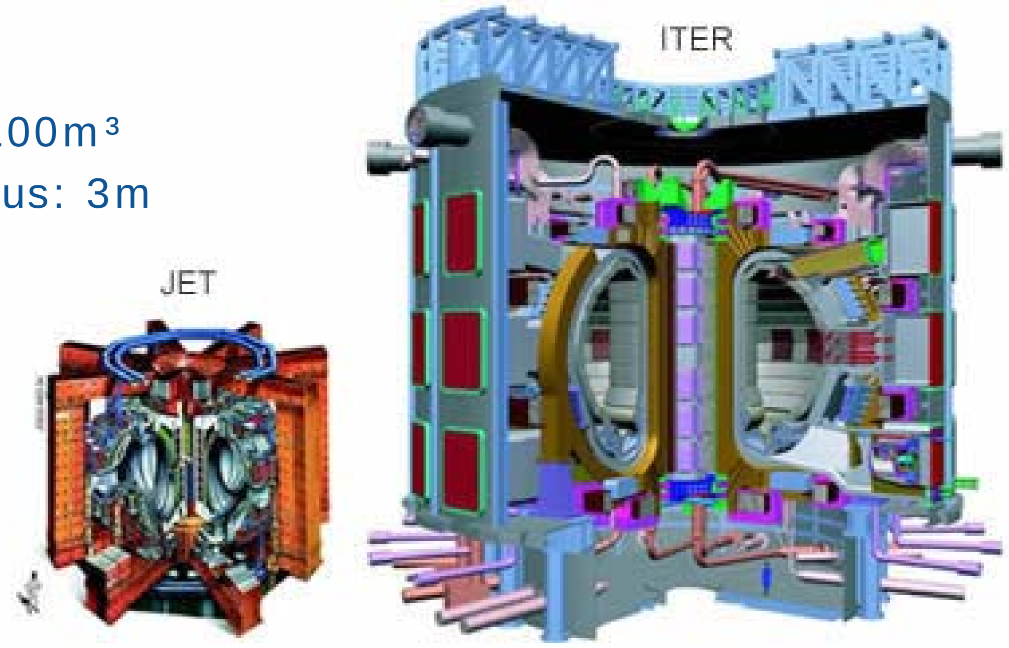
# Size Comparison between JET and ITER

Volume: 100m³
Major radius: 3m

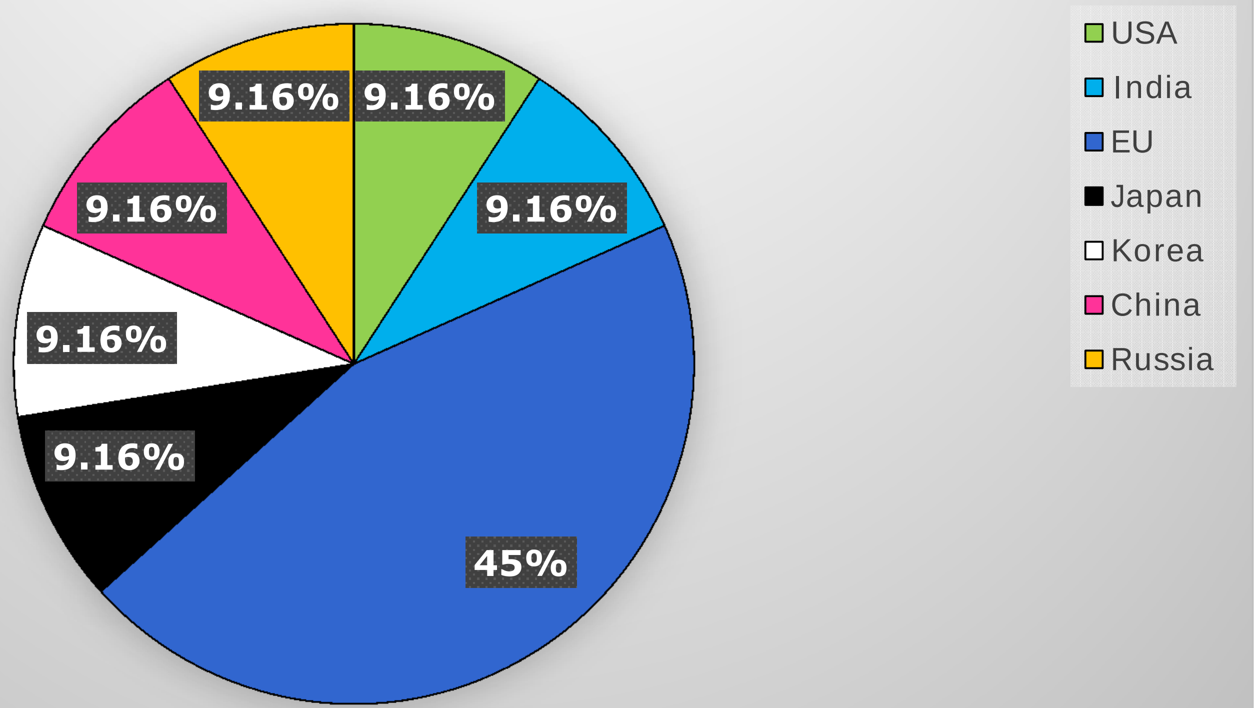
Volume: 840m³
Major radius: 6.2m



- **2001-2006** Coordinated Technical Activities (CTA) and ITER Transitional Arrangements (ITA)
- **2006 ITER Agreement** signed at the Elysée Palace in Paris between China, EU, India, Japan, Korea, Russia and USA (21/11/2006)
- **2007 ITER Organization** officially established following ratification by all members (24/10/2007)

# It takes 34 countries to make ITER

# Countries contribution to the total ITER Budget



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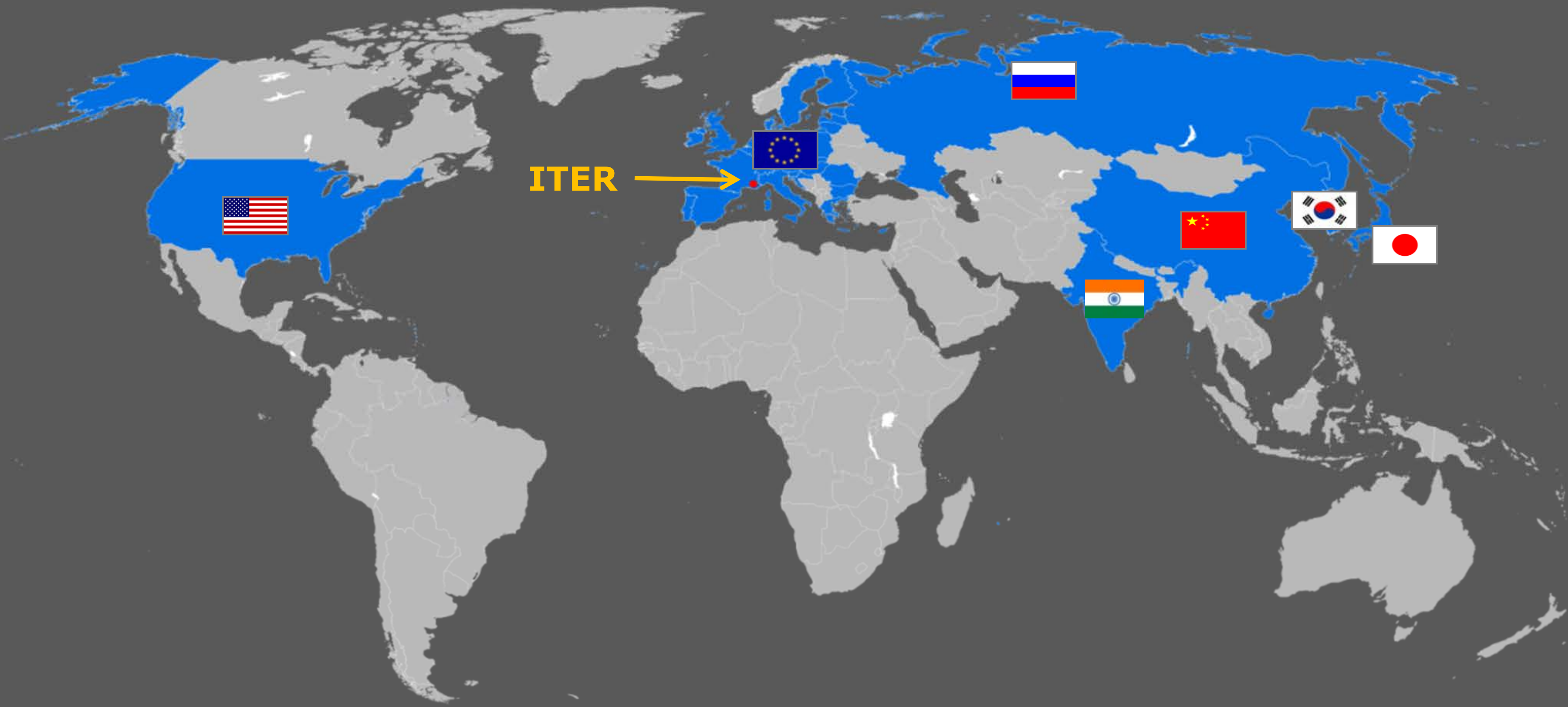
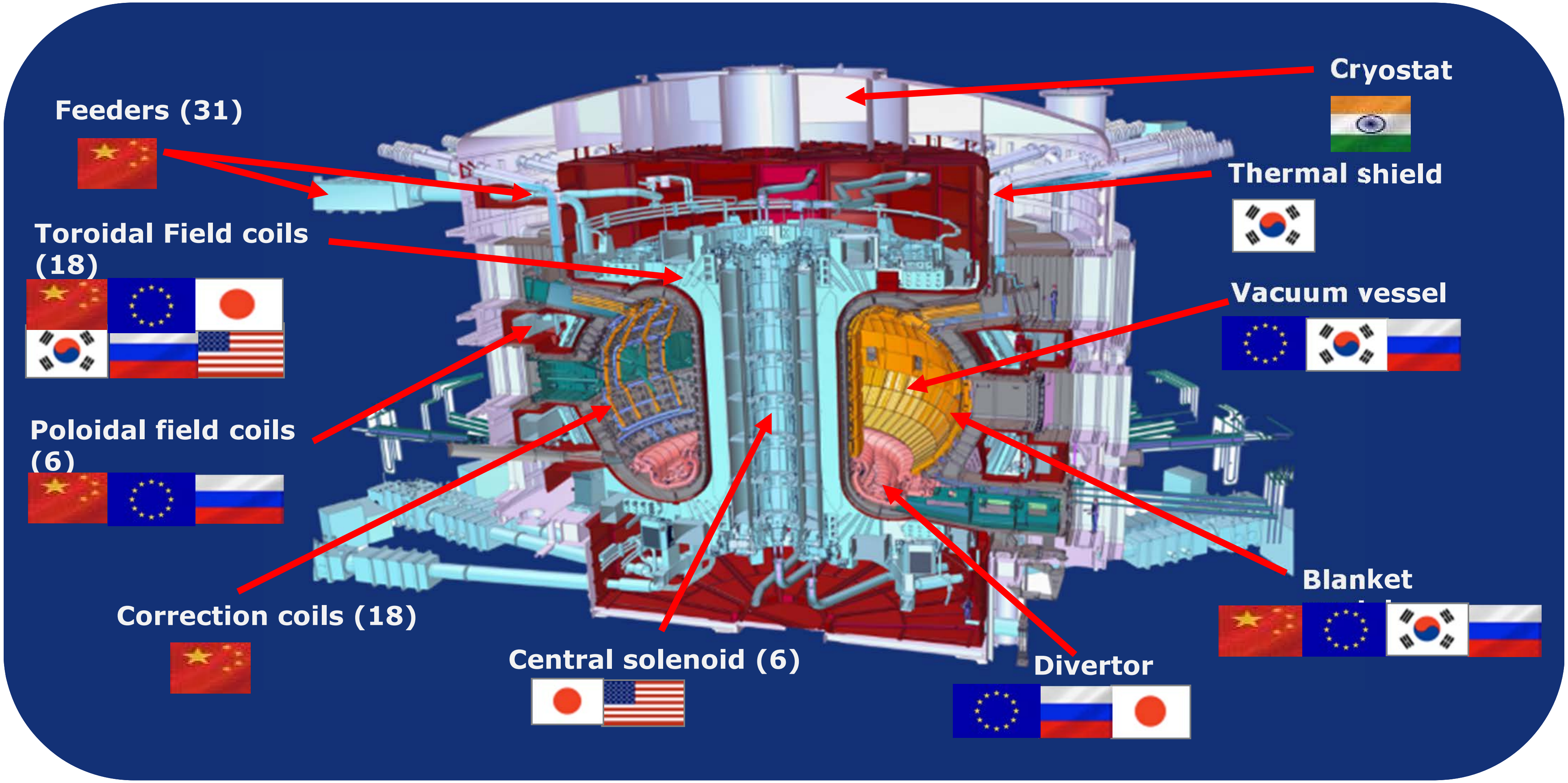
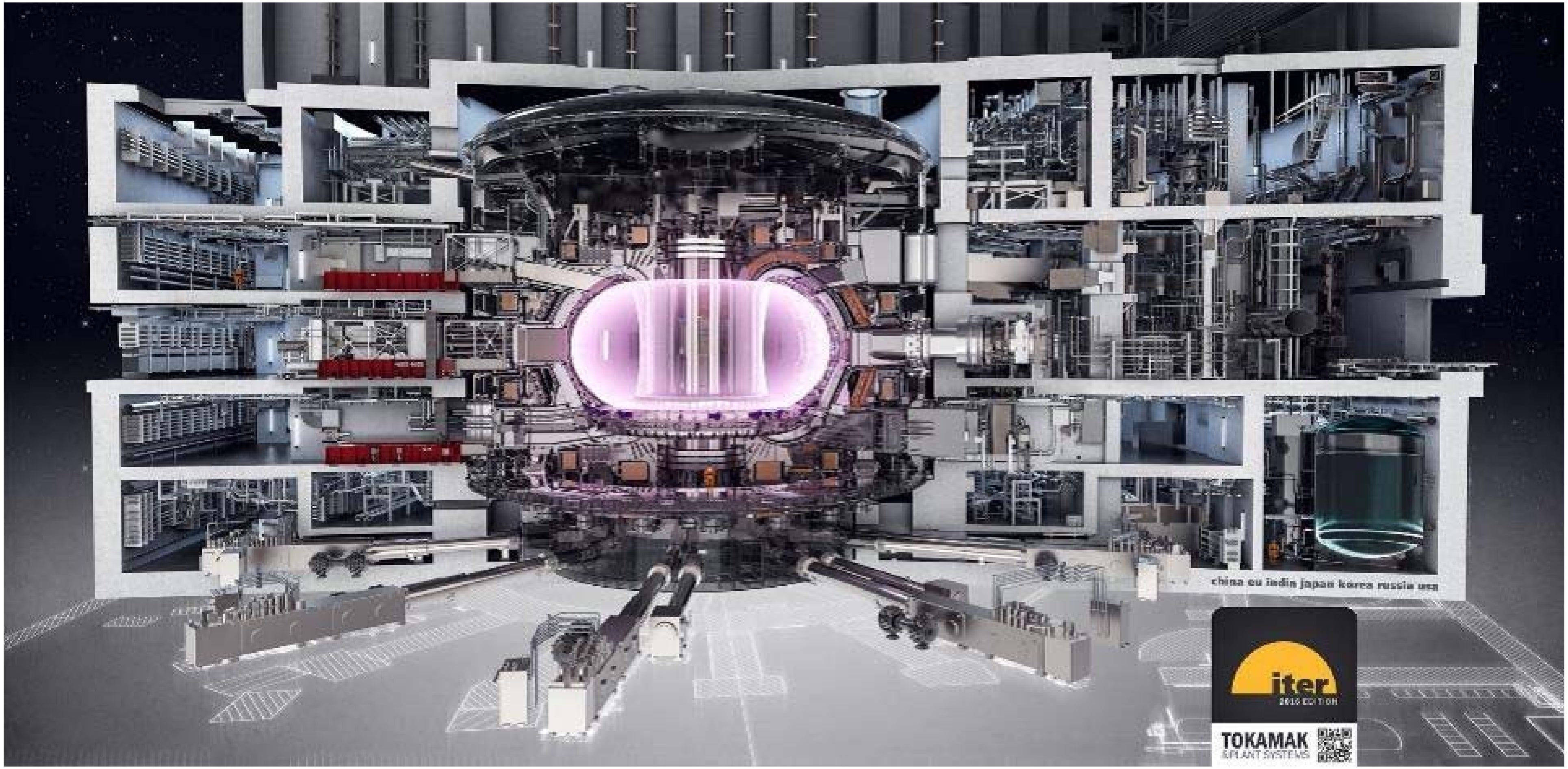


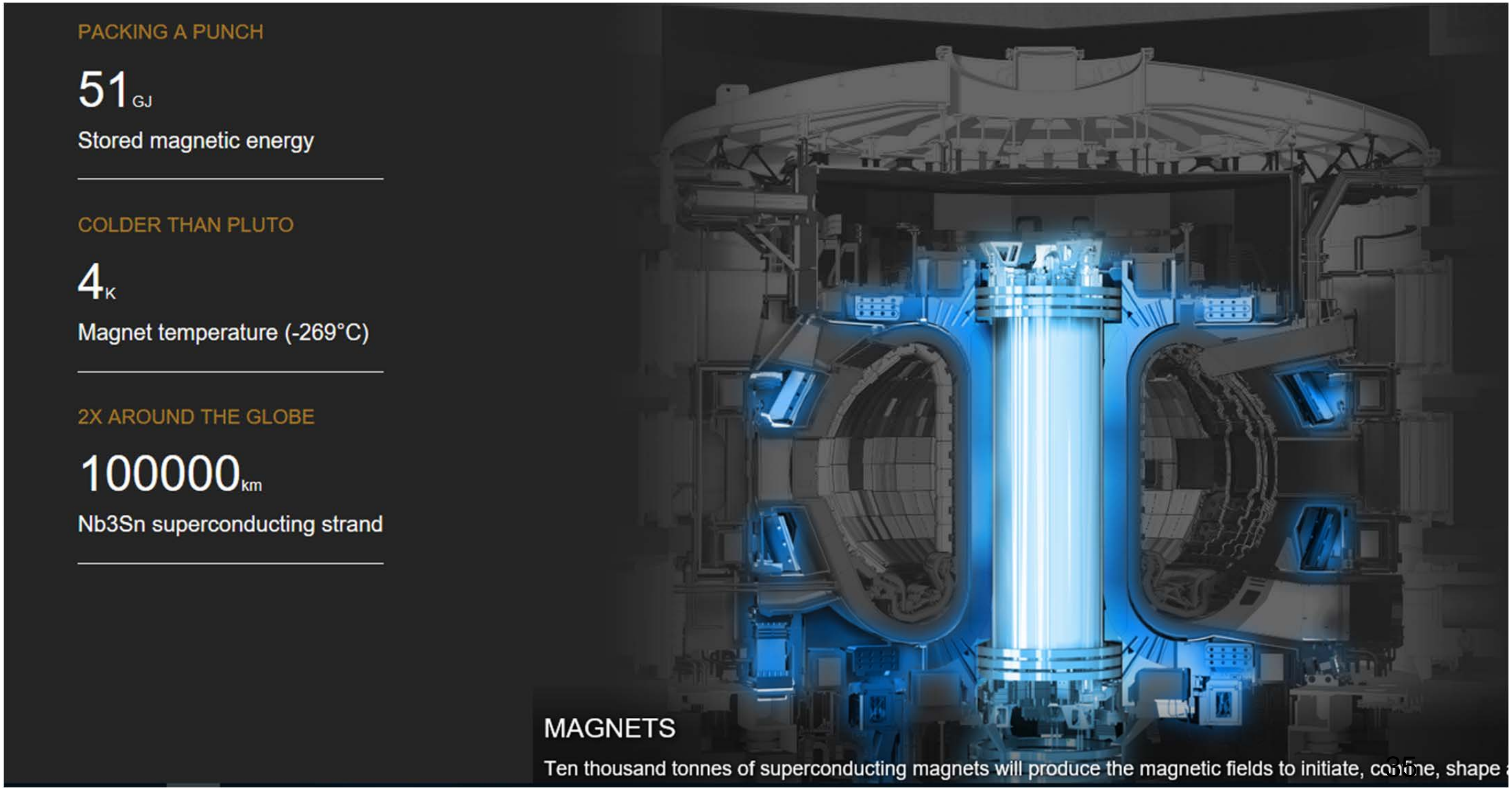
# Individual countries contributions



# Let's talk technology



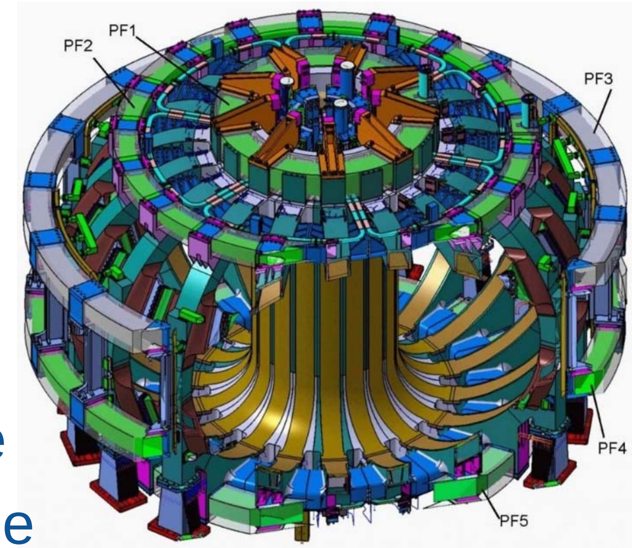
# ITER Magnets



# ITER Magnets

- All of the magnets in ITER are **electromagnets**
- An electromagnet is a magnet made from a coil of wire with electricity running through it
- If the wire is made of a superconducting material, it is a **superconducting electromagnet**
- A superconducting material is one that has no resistance
- Superconducting materials exhibit this property only at very low temperatures

# ITER Magnets Functions



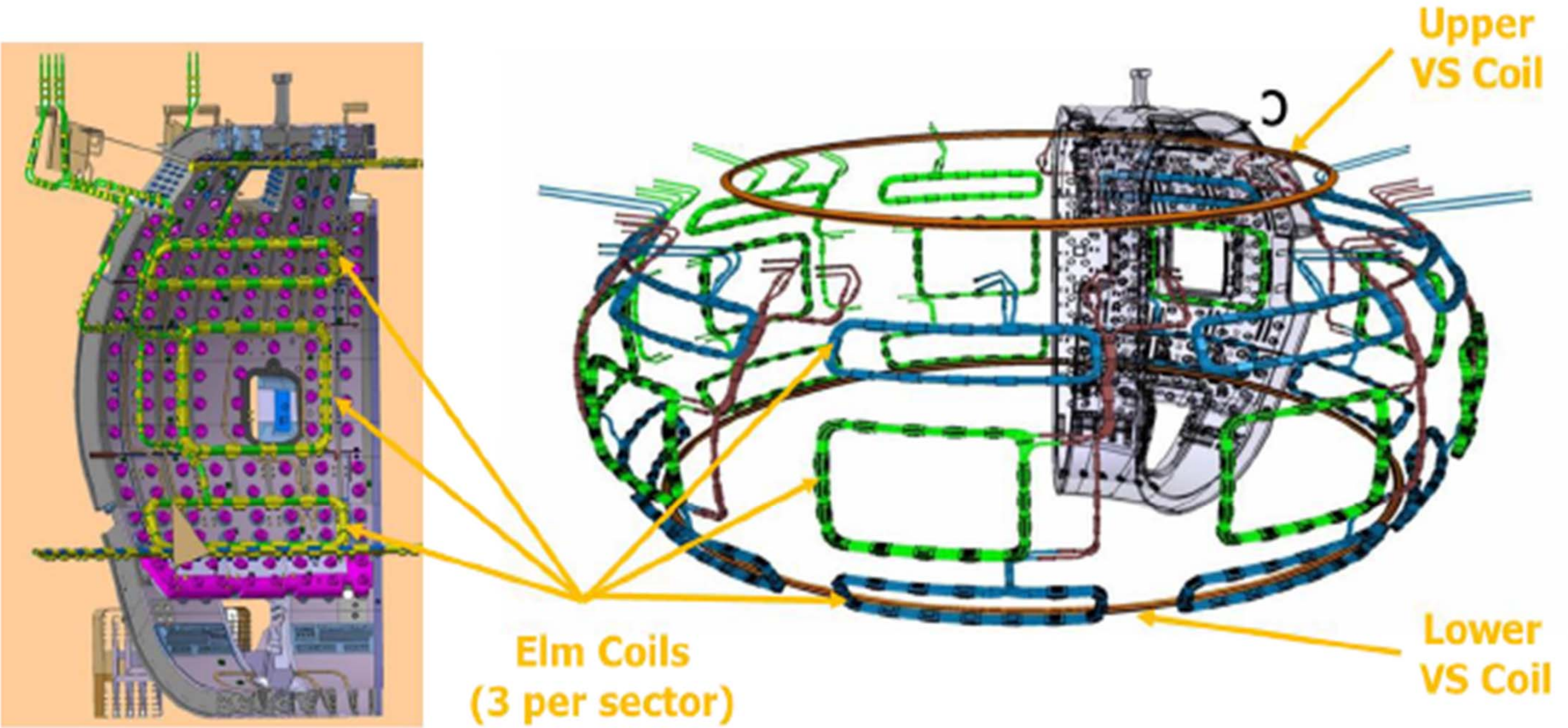

**Outside Vessel:**

| | |
|---|---|
| 1 Central Solenoid | create |
| 18 Toroidal Field coils | confine |
| 6 Poloidal Field coils | position/shape |
| Correction coils | confine, help TF |

**Internal-vessel:**

| | |
|---|---|
| Vertical stability coils | position/stability |
| ELM coils | stability |

# ITER Magnets: In-Vessels Coils

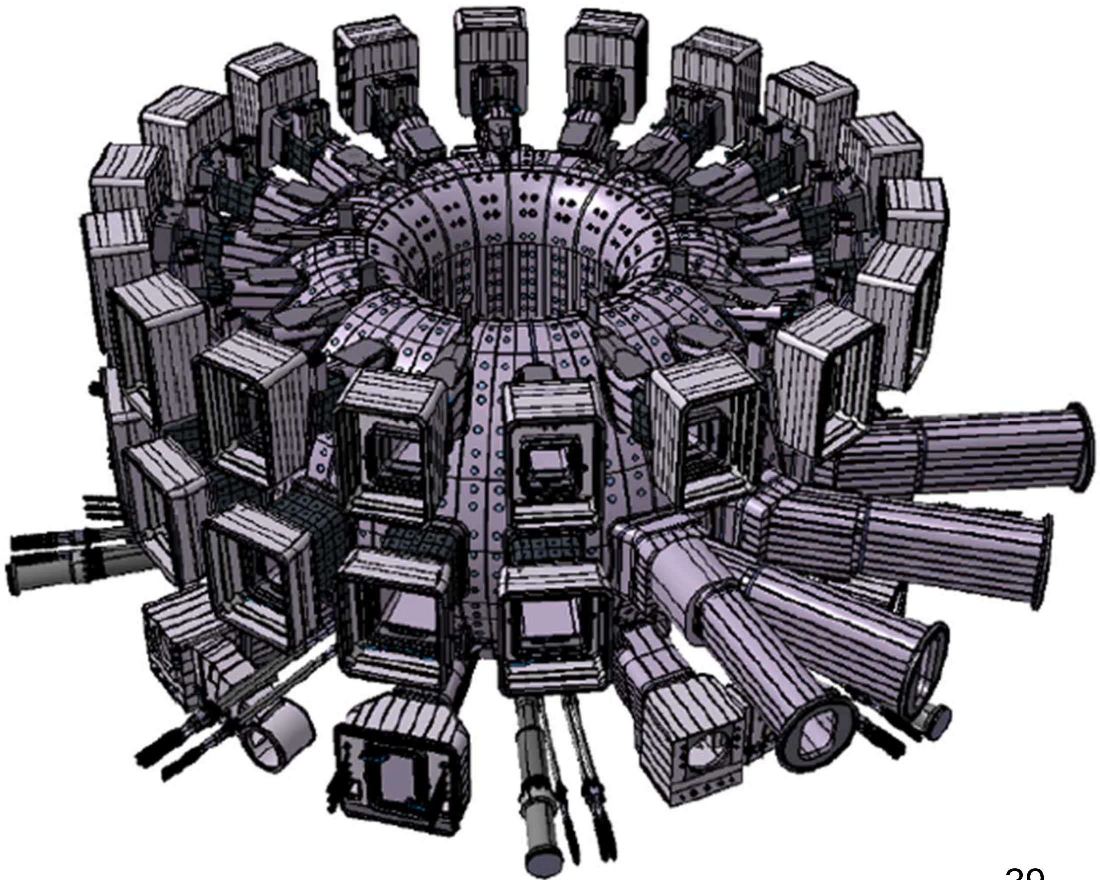


# ITER Vacuum Vessel

Made of welded stainless steel

Height: 20m Diameter: 30m

From the outside, the doughnut shape is hardly visible because the ports conceal it



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# ITER Vacuum Vessel

Toroidal (doughnut-shaped) chamber that contains the plasma

Consists of 9 sectors

Numerous openings for:

- equipment installation
- utility feedthroughs
- vacuum pumping
- plasma heating
- access inside the vessel for maintenance

Inside the vessel, the plasma spirals around without touching the walls

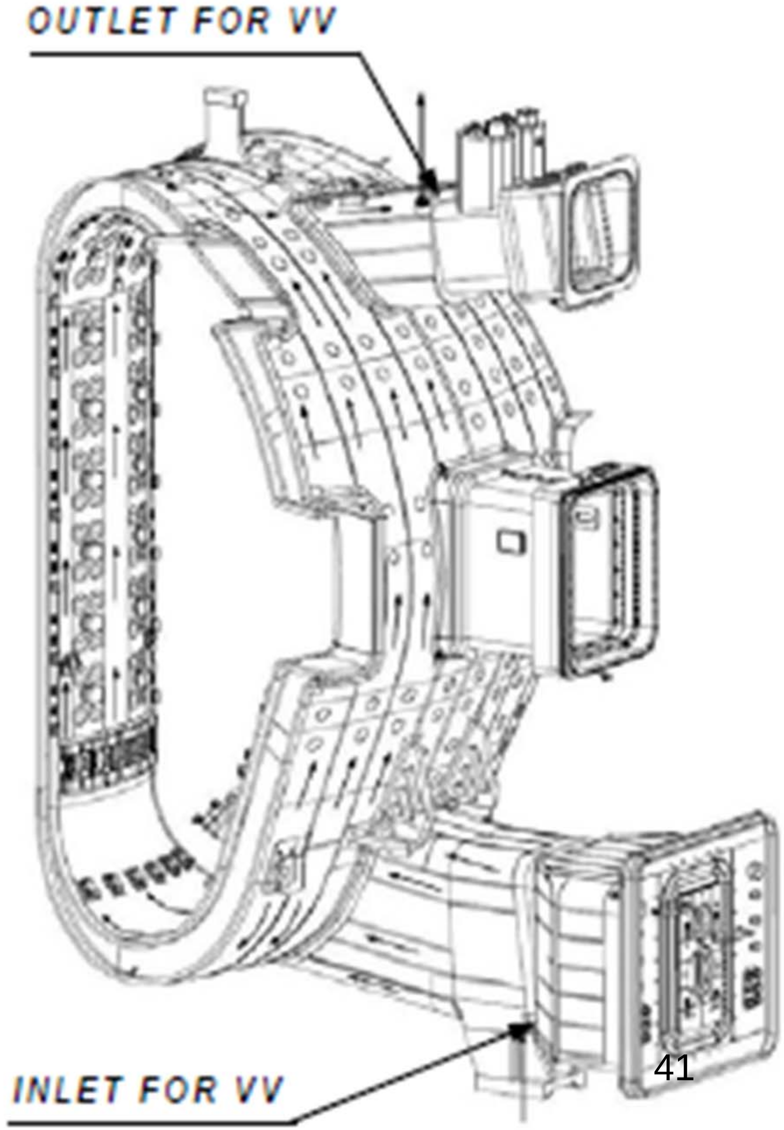
# ITER Vacuum Vessel

Each sector has 3 ports: upper, lower and bottom

Vacuum Vessel has both inner and outer walls

Between walls:

- In-Wall Shielding
- Water flowing for heating or cooling

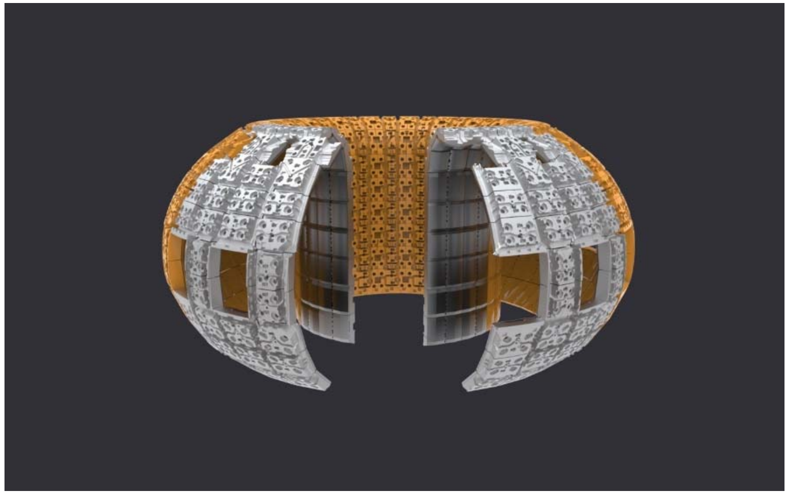


# ITER Blanket

440 blanket modules cover the inside of the Vacuum Vessel

Functions:

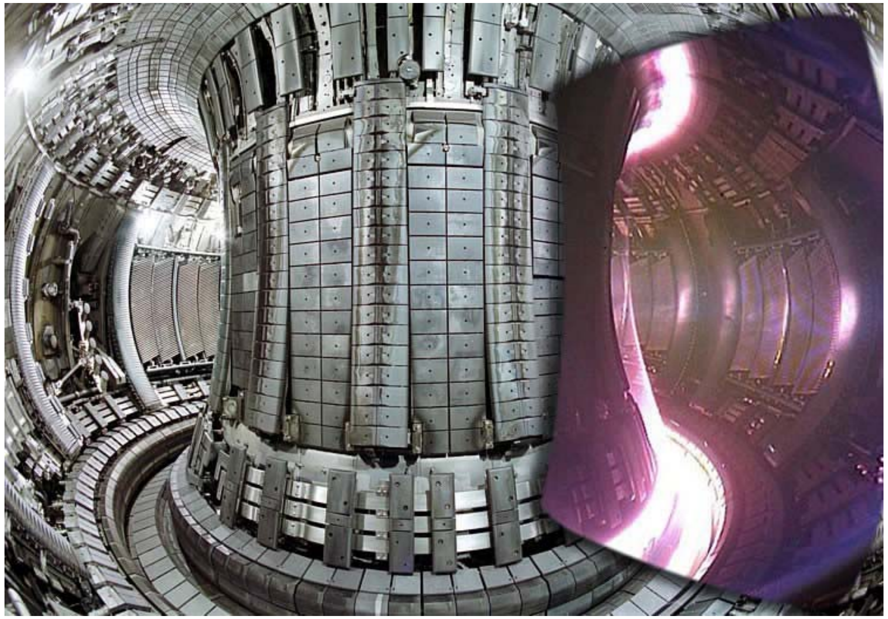
- To protect the steel structure and Toroidal Field Magnets
- To absorb and carry away the kinetic energy of the neutrons produced in the reaction

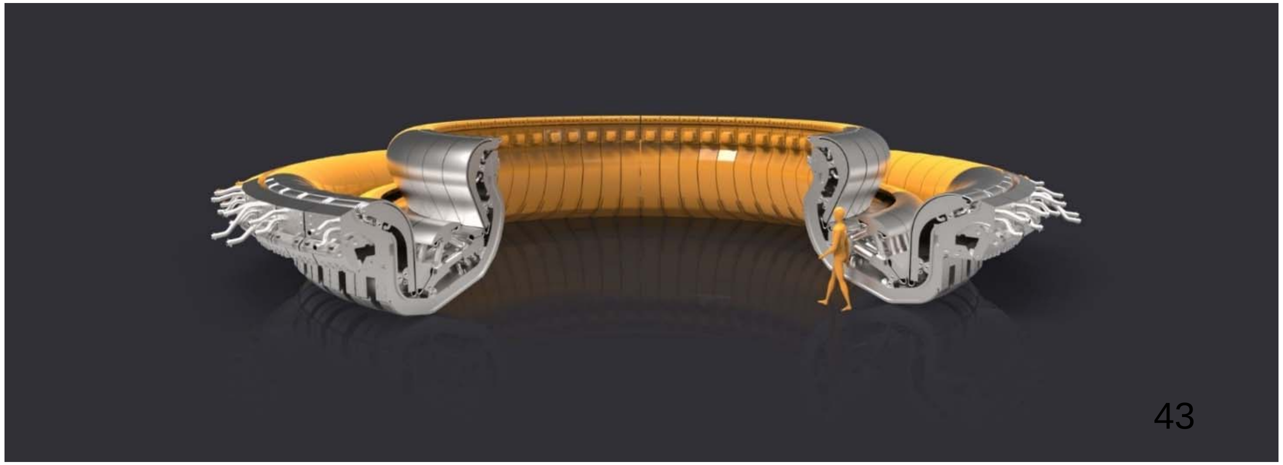


- 600m² surface area
- ITER will be the first machine to have an actively cooled blanket

# The Divertor

- Impurities and waste fall to the bottom of the vessel and are carried away
- ITER's divertor will be made of 54 radial components called cassettes

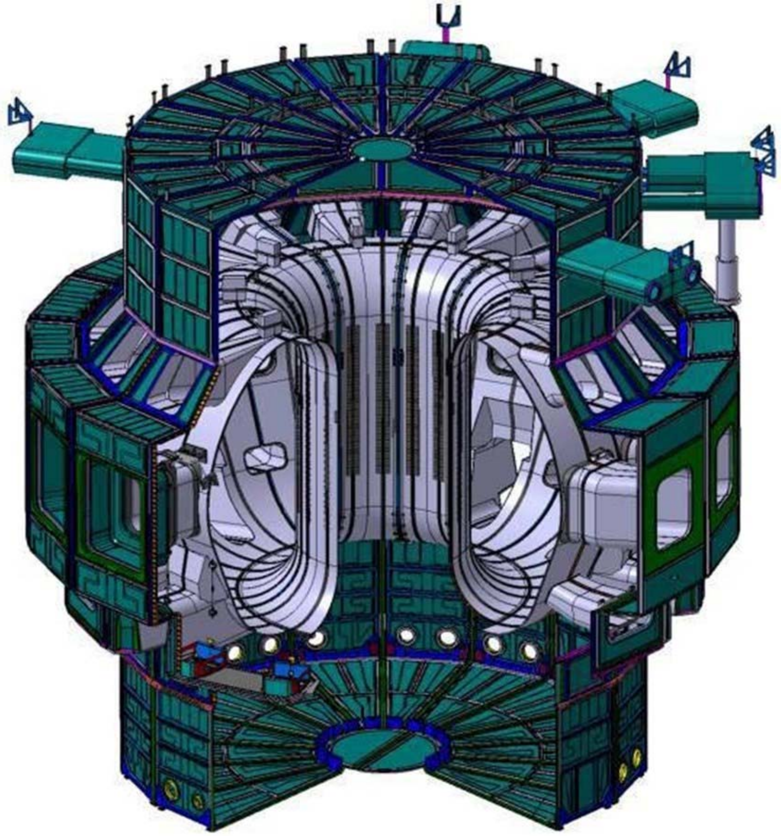




# The Cryostat - Thermal Shield

- The shield is cooled by helium gas at a pressure of 18 bars and a temperature of -193°C or 80K.

- Both sides of the shield are covered by a thin silver coating to reduce thermal radiation

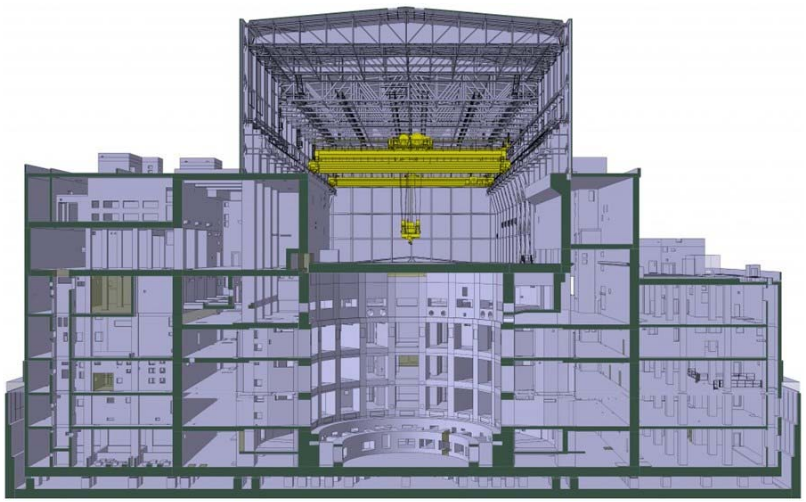


# Buildings

39 buildings on a 180-hectare site

The tokamak complex is a nuclear-rated seven-storey structure made of reinforced concrete.

Next to the tokamak building, there is an Assembly hall for on-site component assembly



- Other buildings include:
  - o a cryoplant
  - o cooling towers
  - o office buildings
  - o hot cell facility

# ITER WORKSITE
## MAIN BUILDINGS

The home of the biggest fusion experiment in history

**Tokamak building**
The home of the ITER machine—a building of seven floors that sits 13 m below the level of the platform and 60 m above

**Cryoplant**
The massive refrigerator of the ITER machine. It houses the compressors, coldboxes, cryogenic tanks and auxiliary systems that will produce cold Nitrogen, and cool liquid Helium

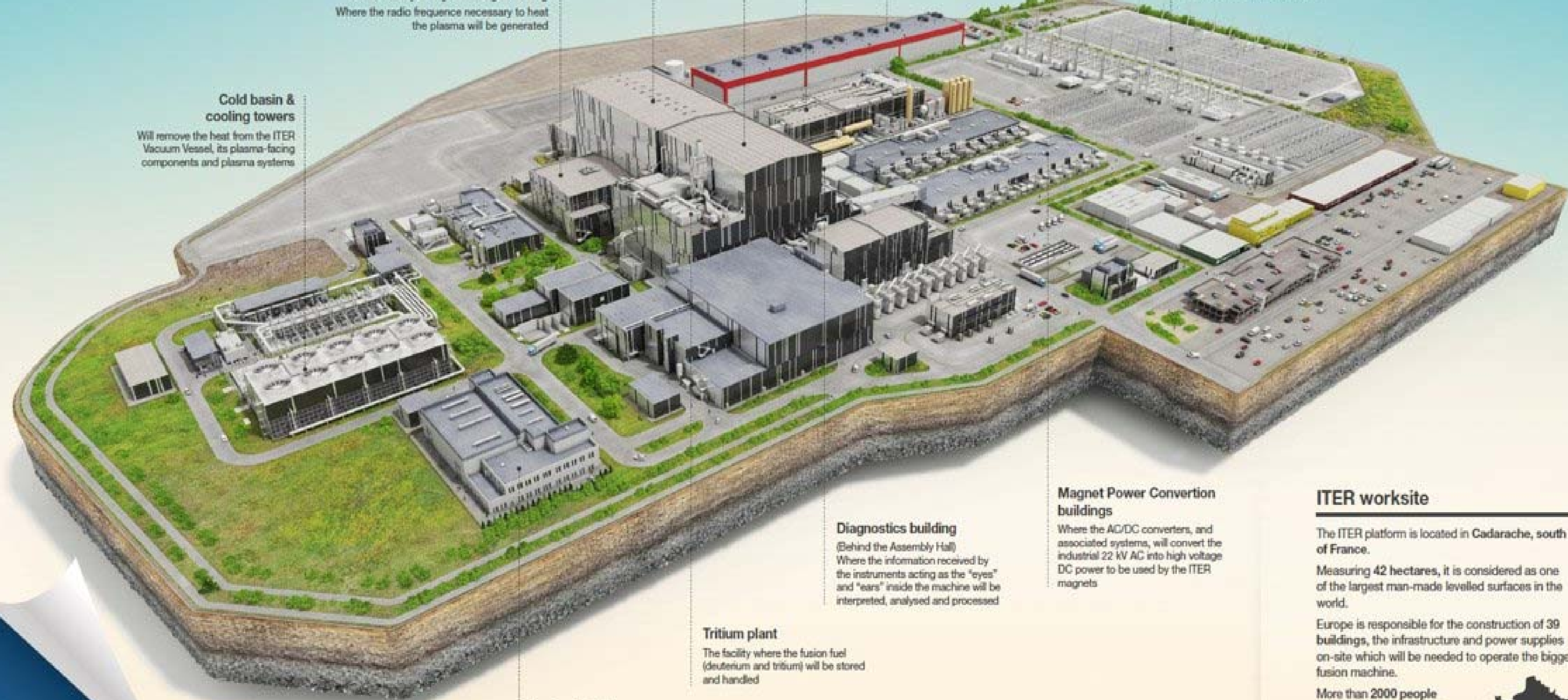
**Poloidal Field coils building**
The factory where Europe is manufacturing four of its PF coils measuring between 17 and 25 m in diameter and weighing between 200 and 400 t

**Assembly Hall**
The immense workshop where various ITER components will be assembled

**High voltage**
ITER is connected to France's national grid. Thanks to the ITER transformers the 400kV received will be converted to 22 KV and 66 KV for the needs of the ITER site and components.

**Radio Frequency Heating building**
Where the radio frequence necessary to heat the plasma will be generated

**Cold basin & cooling towers**
Will remove the heat from the ITER Vacuum Vessel, its plasma-facing components and plasma systems



**Diagnostics building**
(Behind the Assembly Hall)
Where the information received by the instruments acting as the "eyes" and "ears" inside the machine will be interpreted, analysed and processed

**Magnet Power Convertion buildings**
Where the AC/DC converters, and associated systems, will convert the industrial 22 kV AC into high voltage DC power to be used by the ITER magnets

**Tritium plant**
The facility where the fusion fuel (deuterium and tritium) will be stored and handled

**Control building**
The facility from where the ITER machine will be operated

## What is ITER?

ITER is the next major milestone on the path to fusion energy. It will allow scientists to study a 'burning plasma' that releases more energy than used to produce it, and will rely on an impressive range of technologies that will be essential to deliver fusion power in the future.

ITER is a global scientific partnership of unprecedented scale bringing together half of the world's population: China, Europe, Japan, India, the Republic of Korea, the Russian Federation and the United States, which together represent 80% of the global GDP.

Fusion for Energy (F4E) manages Europe's contribution to ITER which amounts to roughly half of the project.

## ITER worksite

The ITER platform is located in **Cadarache, south of France.**

Measuring **42 hectares,** it is considered as one of the largest man-made levelled surfaces in the world.

Europe is responsible for the construction of **39 buildings,** the infrastructure and power supplies on-site which will be needed to operate the biggest fusion machine.

More than **2000 people** are contributing to ITER's building works.


FUSION FOR ENERGY
www.f4e.europa.eu

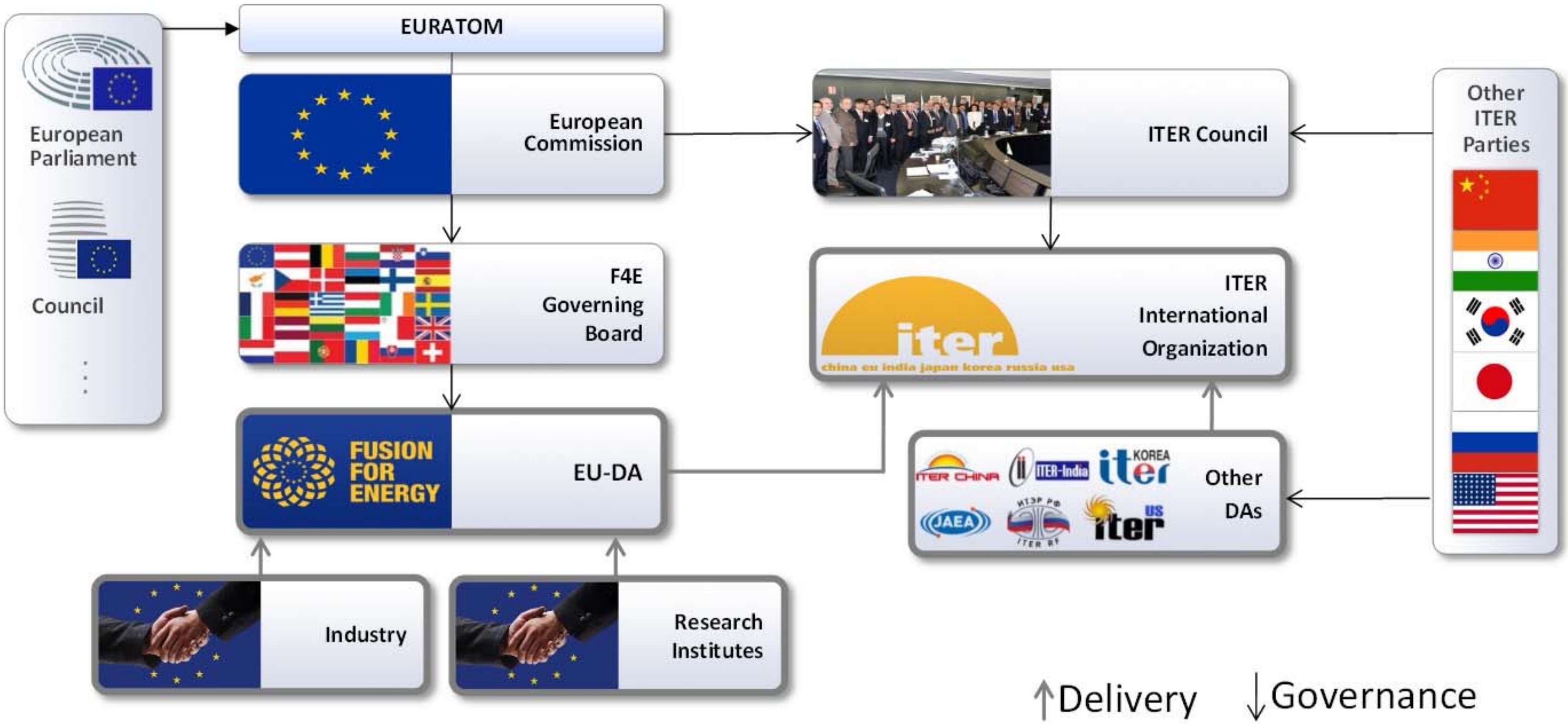
# Extra References

**Videos: Let there be Light**

**fusion.film/LTBL/**

**Publications: Eurofusion**

# ITER Governance



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## Fusion for Energy or "F4E" is the European Union agency for ITER

- F4E is an Euratom Joint Undertaking set up in 2007 for 35 years
- 29 Members States (EU28 + CH)
- Headquarters: Barcelona, Spain
  Offices: Cadarache, France
  Garching, Germany
- Members of staff: ~ 467 (mostly engineers and scientists)
- Budget: €6.6 billion (2007-2020) mostly for the construction of ITER

# F4E Missions and Responsibilities

FUSION FOR ENERGY



## 1. VISION AND OVERALL F4E MISSION

*"Bringing the power of the sun to earth"*

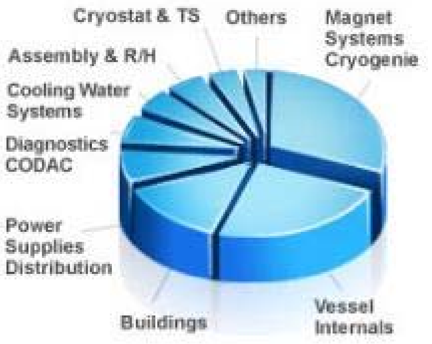
This vision communicates the active role Fusion for Energy (F4E) takes in advancing fusion towards becoming a reliable source of clean abundant base load energy.

F4E is the European centre to develop and build ITER and other facilities to turn fusion into a sustainable source of energy for mankind. F4E bridges the EU research community and the EU industry, to broaden the European industrial base for fusion technology. F4E was set up for 35 years from 19 April 2007 with a threefold mission:

1. To provide the contribution of the European Atomic Energy Community (Euratom) to the ITER International Fusion Energy Organisation;
2. To provide the contribution of Euratom to Broader Approach Activities with Japan for the rapid realisation of fusion energy;
3. To prepare and coordinate a programme of activities in preparation for the construction of a demonstration fusion reactor and related facilities including the International Fusion Materials Irradiation Facility (IFMIF).

# ITER procurement packages


Each party is manufacturing different components of ITER and delivering them to the project




Europe is the main "shareholder" in the project (45%)

Europe is providing around half of the components

F4E's activity is working with:

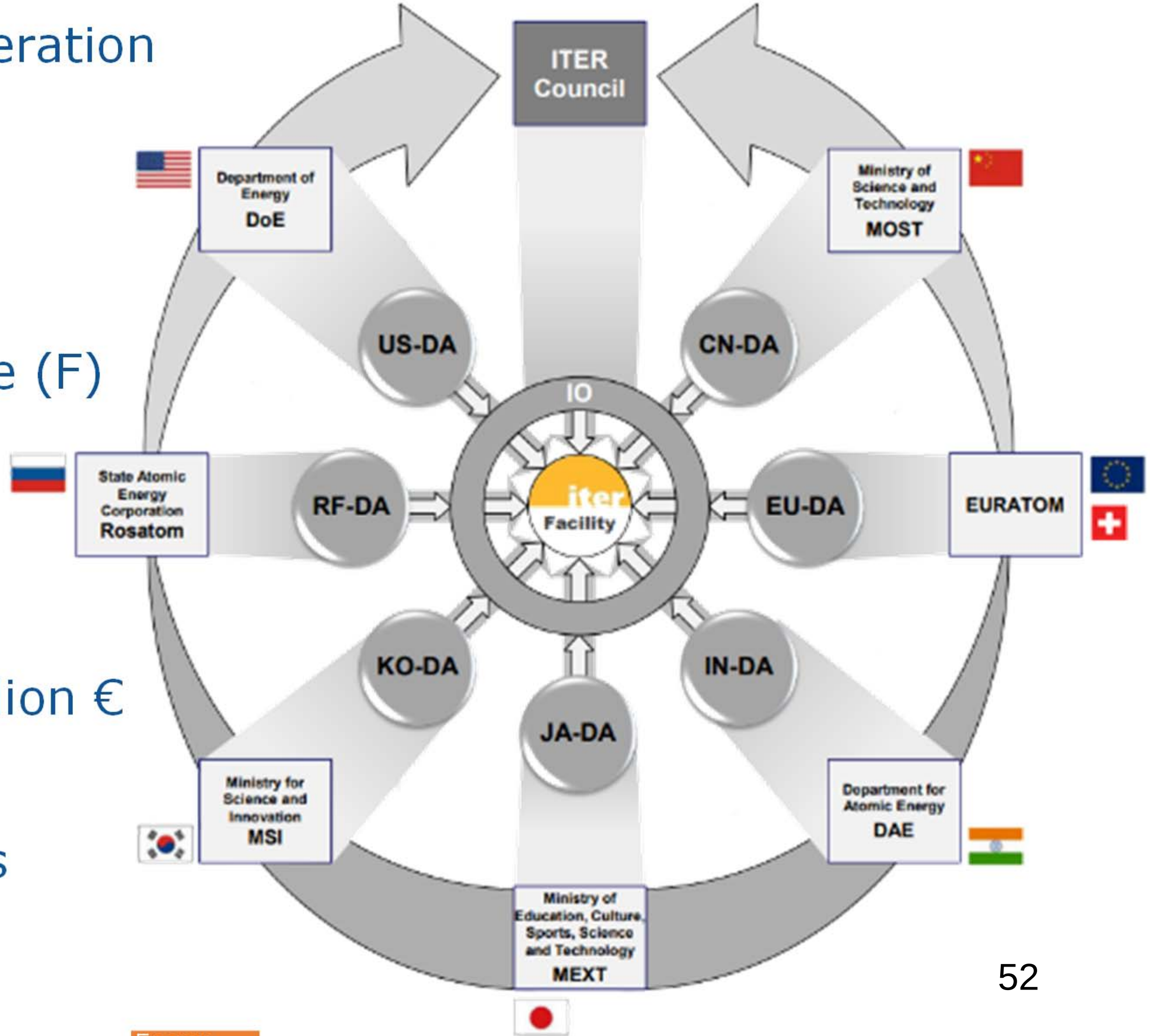
- EU industry
- SMEs
- Fusion Labs

to design and build ITER components

European Commission

# ITER Organization (IO)

- Design, integration & operation
- 7 international parties
- Headquarters: Cadarache (F)
- Staff: ~800
- Budget to 2020: ~2.6 billion €
- IO interacts with the DAs






Energy

# 2016 Baseline

- In April 2016, recommendations of an independent review on the updated ITER schedule supporting the *'stage approach'* (ICRG)

- In November 2016, the ITER Council endorsed the revised schedule:

  ✓ Construction activities continue beyond 2025 in the operation phase until 2035 ("Final Installation activities")

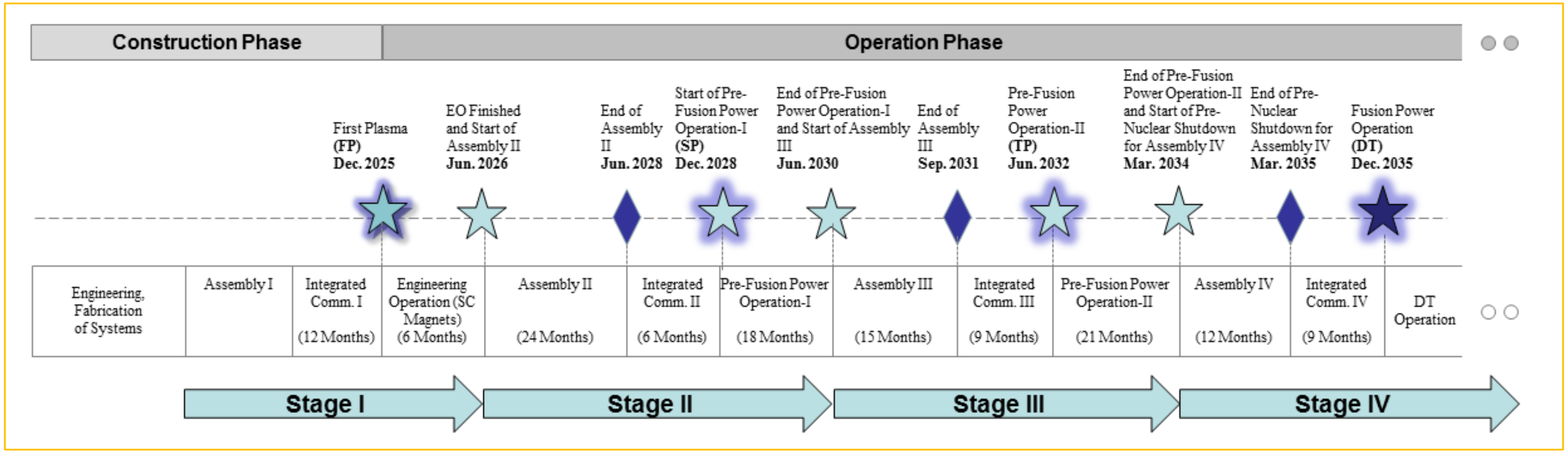
- Approved *ad referendum* the cost for the Construction and Operation Phases

  ✓ keeping First Plasma for December 2025; and

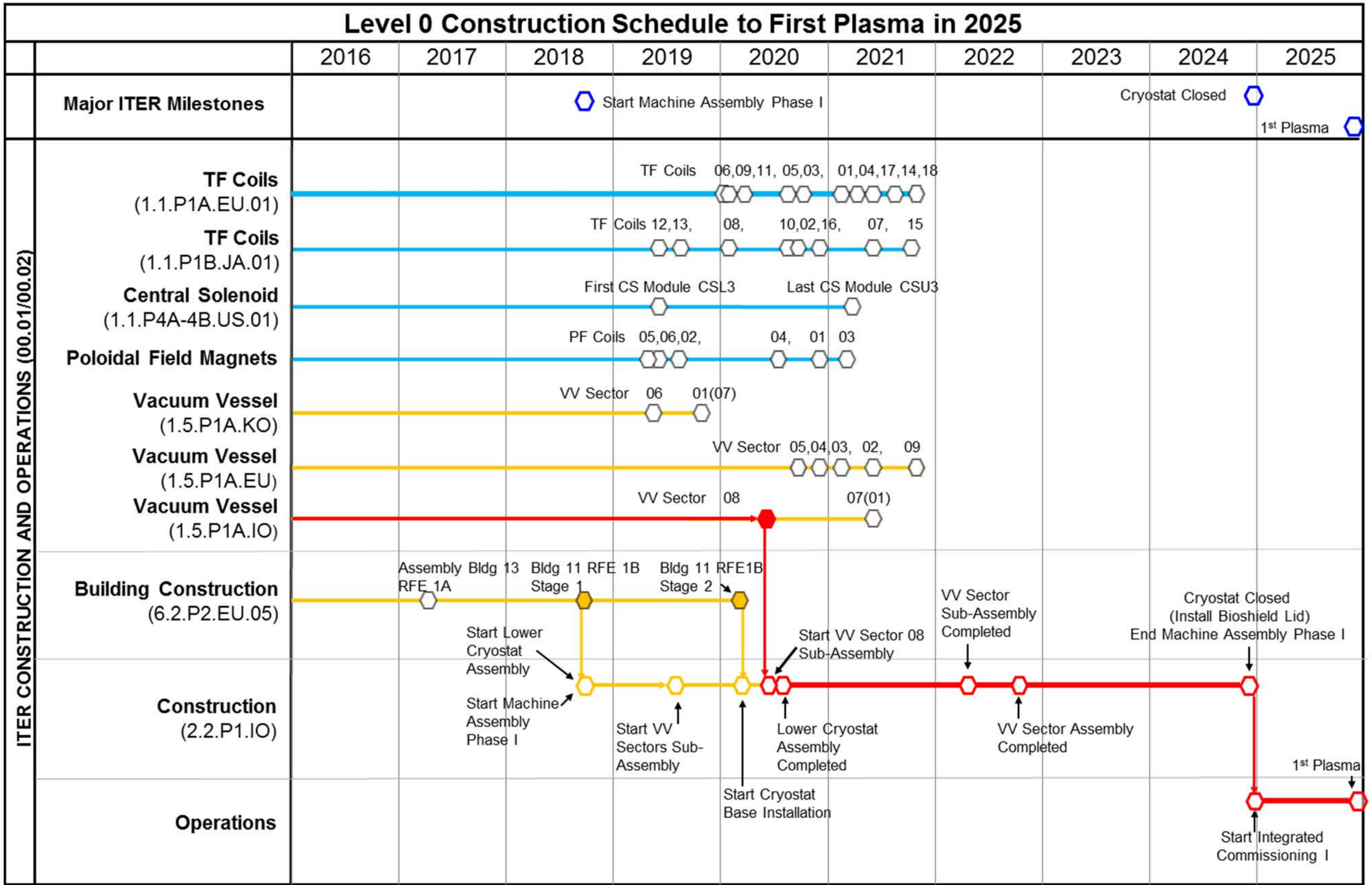
  ✓ fixing the start of Fusion Power for December 2035

# Staged approach

- Proposed use of 4-stage approach through Deuterium-Tritium (2035) consistent with Members' financial and technical constraints
- Provides focus on necessary components to achieve First Plasma (2025) consistent with Members' budget constraints

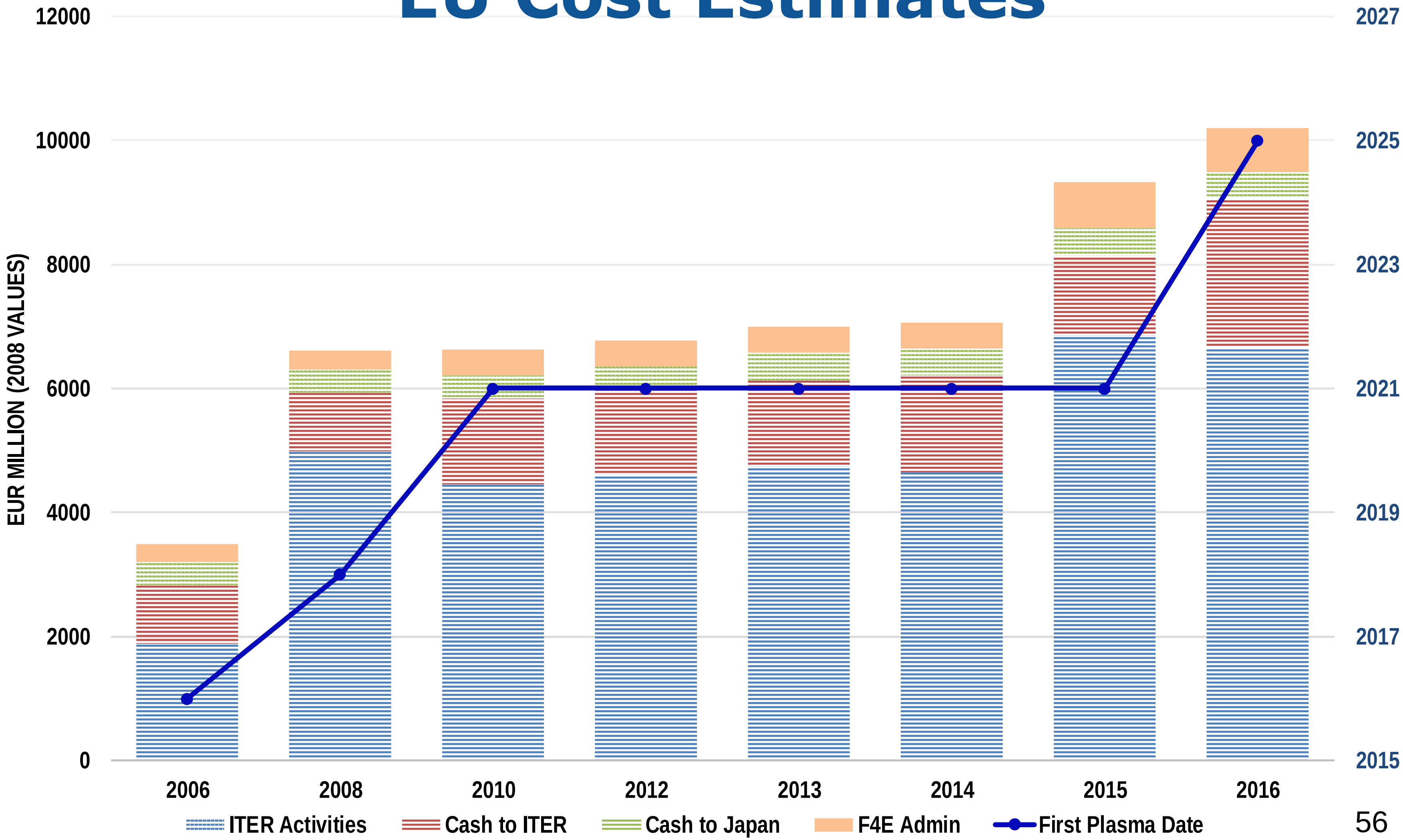


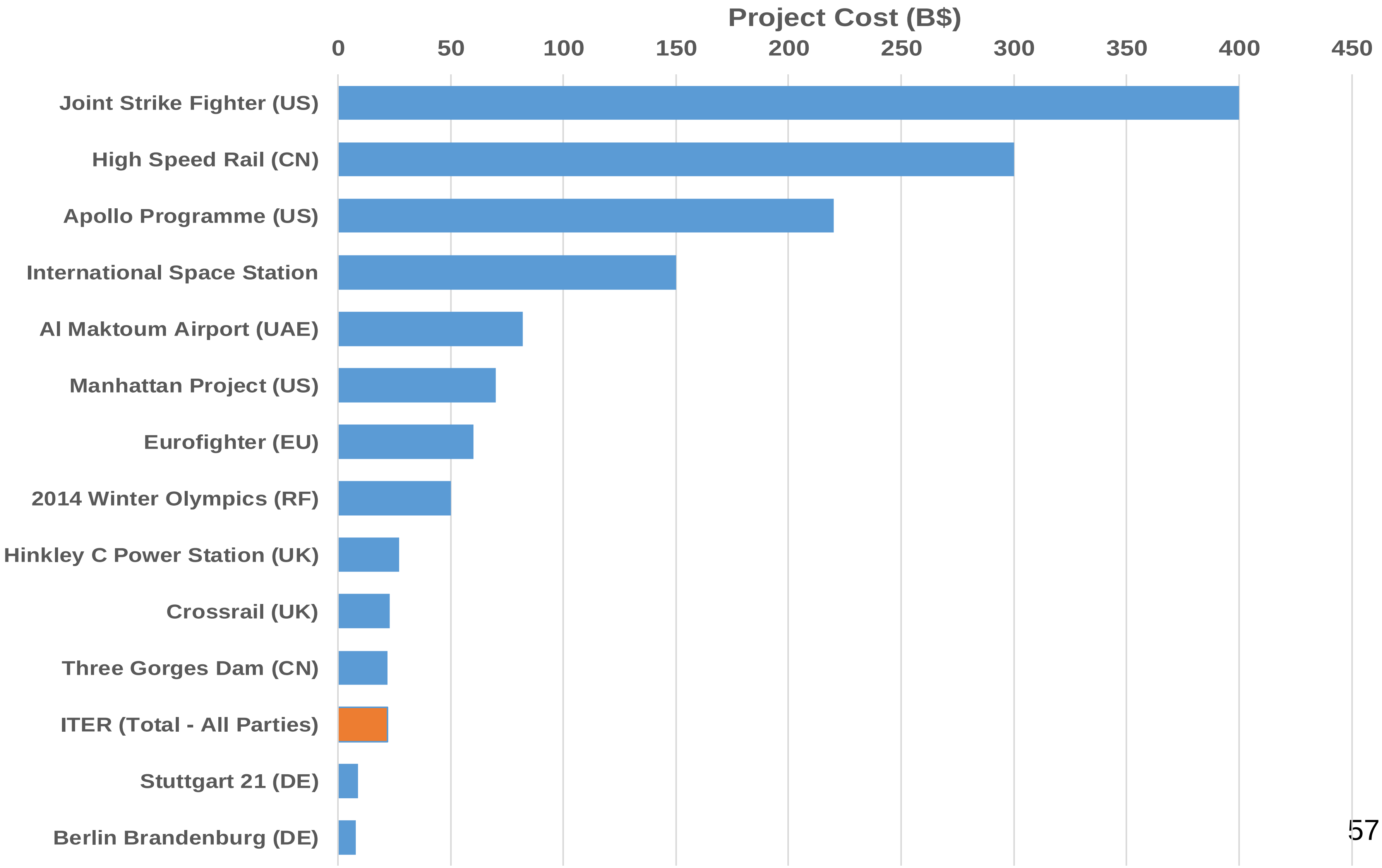
European
Commission

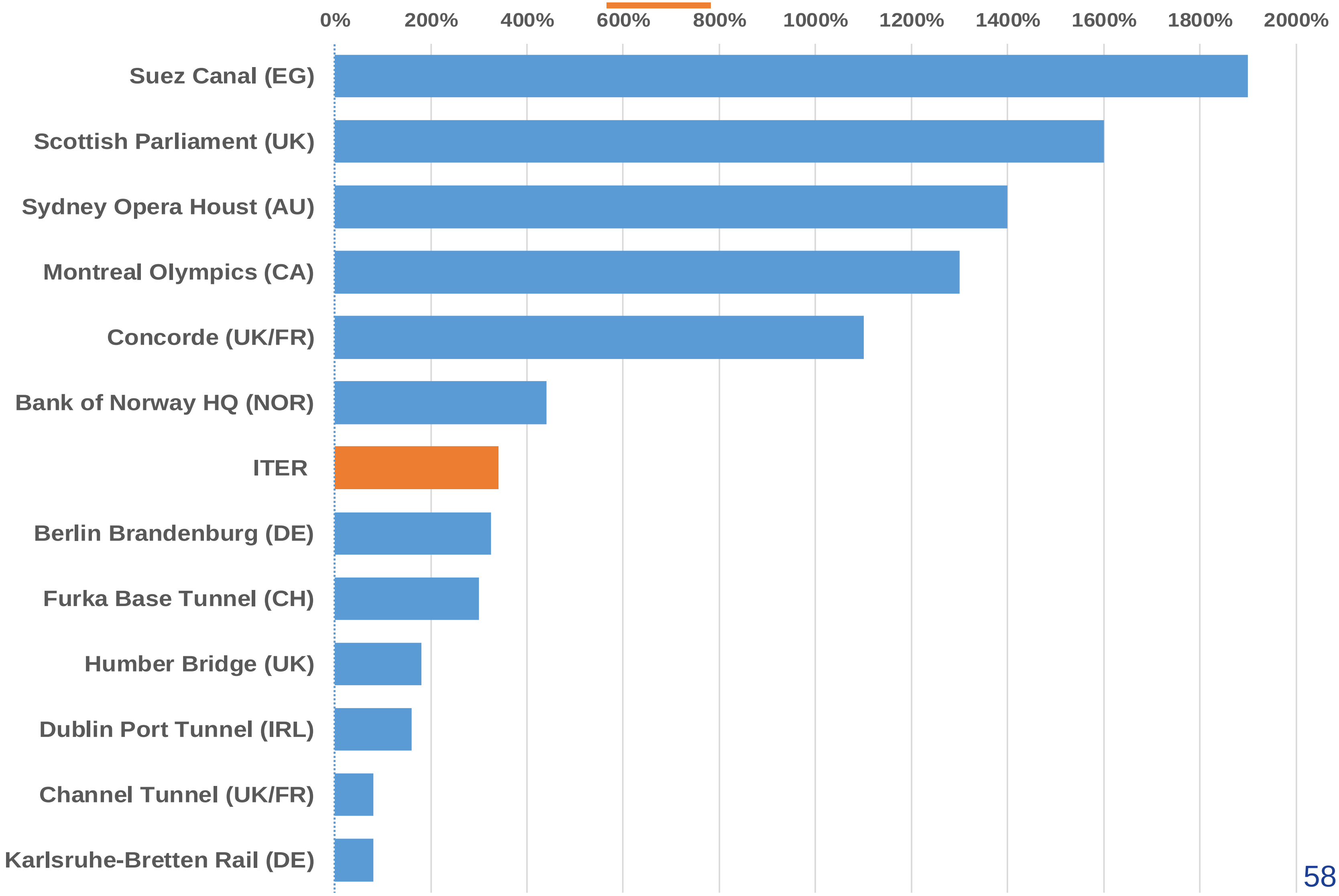



Energy

# EU Cost Estimates




Project Cost (B$)
0
50
100
150
200
250
300
350
400
450
Joint Strike Fighter (US)
High Speed Rail (CN)
Apollo Programme (US)
International Space Station
Al Maktoum Airport (UAE)
Manhattan Project (US)
Eurofighter (EU)
2014 Winter Olympics (RF)
Hinkley C Power Station (UK)
Crossrail (UK)
Three Gorges Dam (CN)
ITER (Total - All Parties)
Stuttgart 21 (DE)
Berlin Brandenburg (DE)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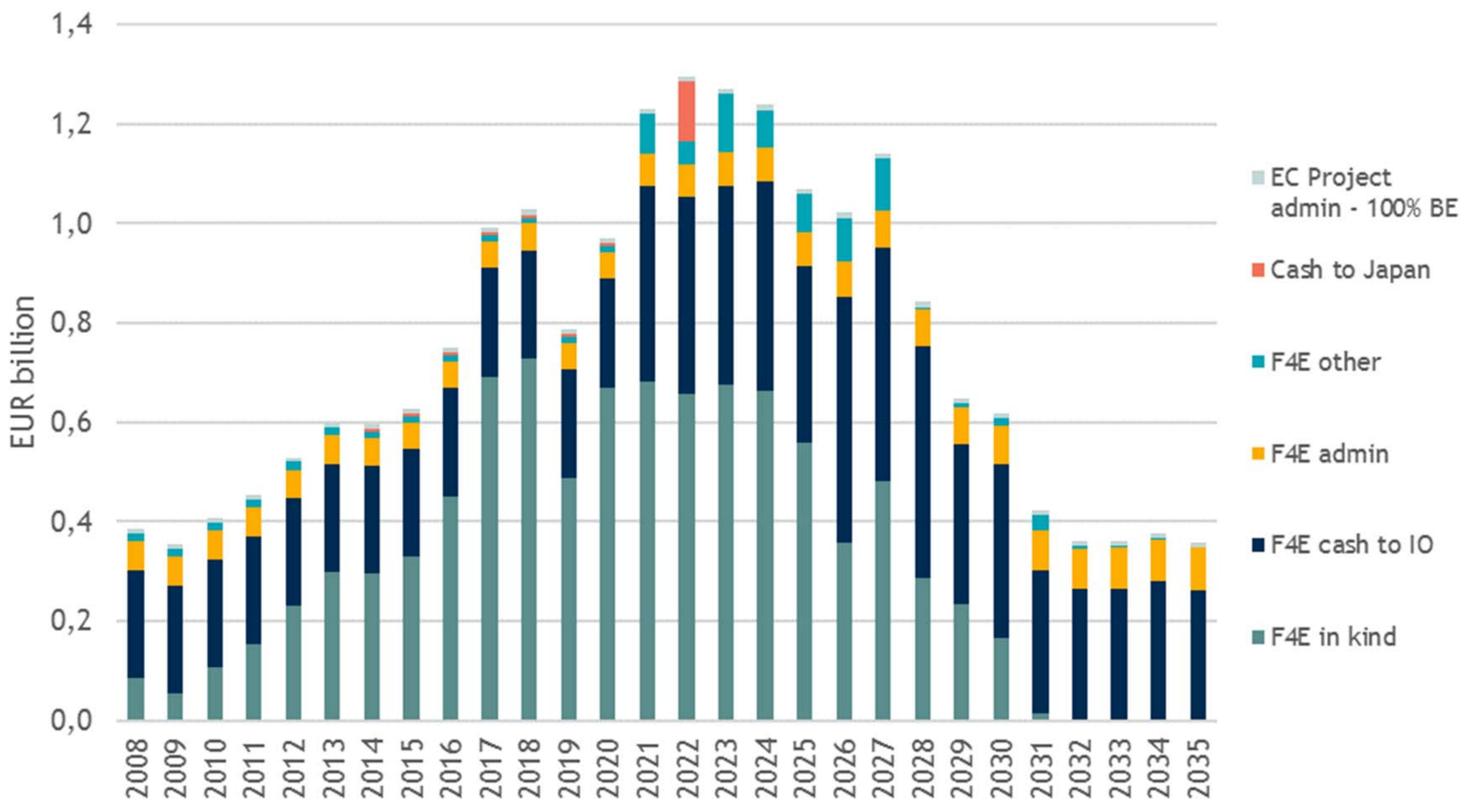
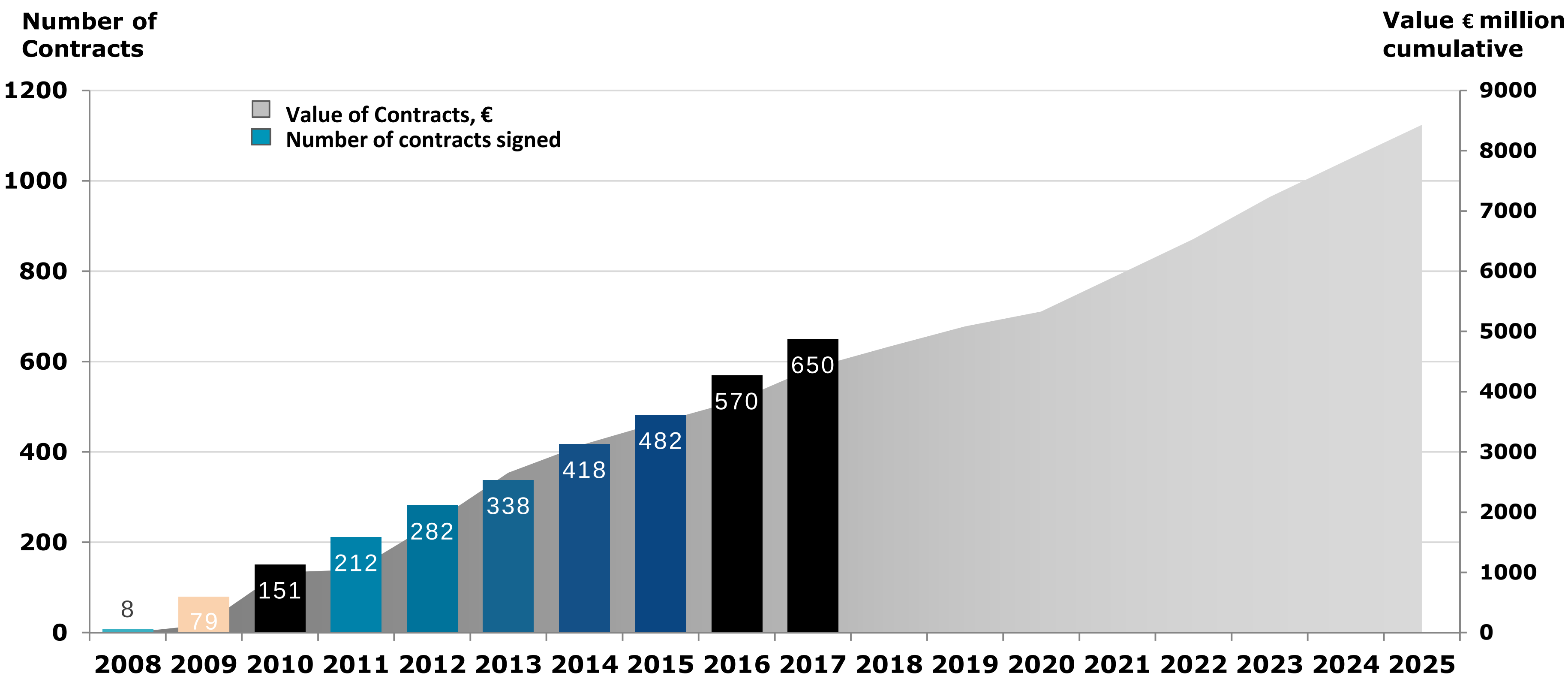
Sydney Opera Houst (AU)
Montreal Olympics (CA)
Concorde (UK/FR)
Bank of Norway HQ (NOR)
ITER
Berlin Brandenburg (DE)
Furka Base Tunnel (CH)
Humber Bridge (UK)
Dublin Port Tunnel (IRL)
Channel Tunnel (UK/FR)
Karlsruhe-Bretten Rail (DE)

# The European contribution to ITER

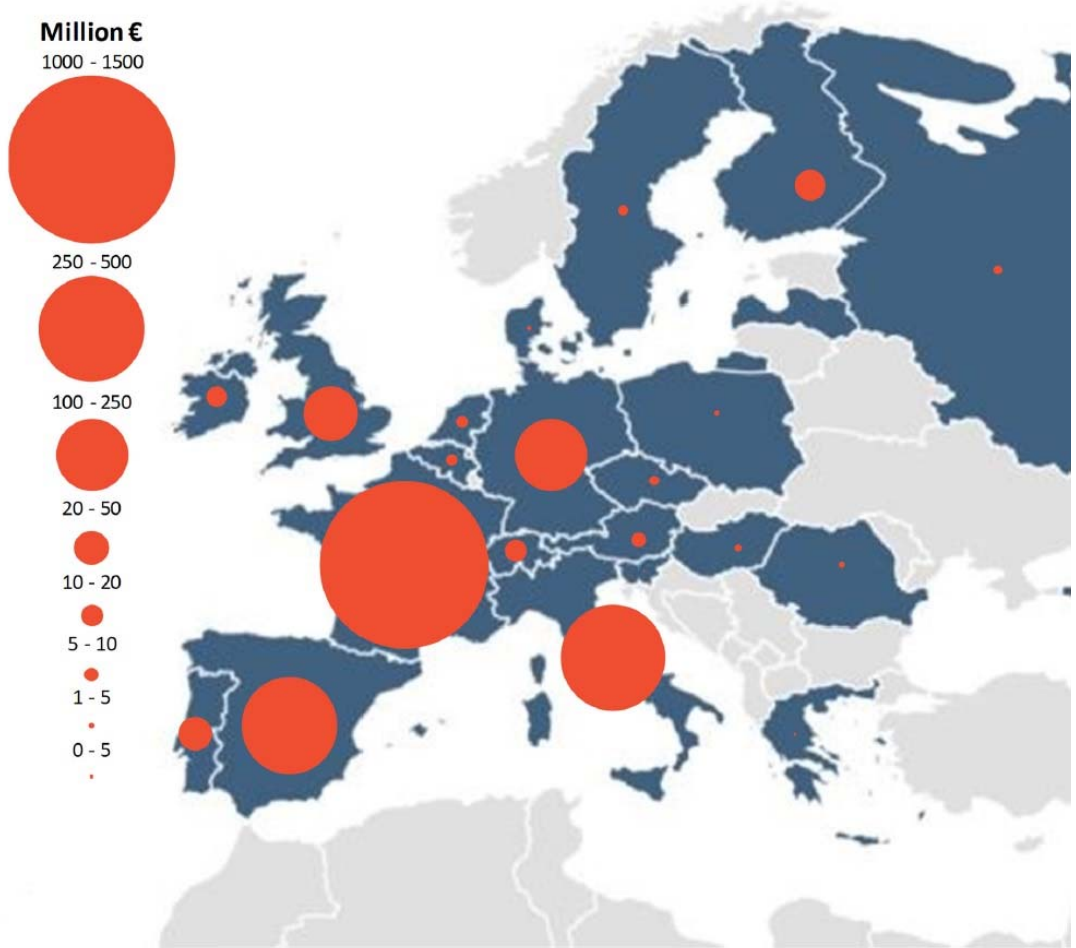


# €4.5 billion through 923 signed contracts (2008-2017)




***Working with ~450 contractors and >1000 sub-contractors in 24 countries***

# The European contribution to ITER




Top Contributors:

- 1st France
- 2nd Spain
- 3rd Italy
- 4th Germany
- 5th UK

2016: New project baseline

COM Communication (June 2017)

Council Conclusions (April 2018)

MFF Proposal (May 2018)

Legislative Proposal (June 2018)

European Commission

# ITER in the next MFF (2021-2027)

- 14 June 2017: Commission Communication "EU contribution to a reformed ITER Project"
- 12 April 2018: Adoption of Council Conclusions on ITER
- Broadly supportive of the project; a mandate to approve the baseline
- 2 May 2018: Proposal of the 2021-2027 MFF (EUR6,07B)
- 5 January 2019: EP approved the ITER own initiative report at the plenary
  - ✓ Under discussion in the Council under the Romanian presidency

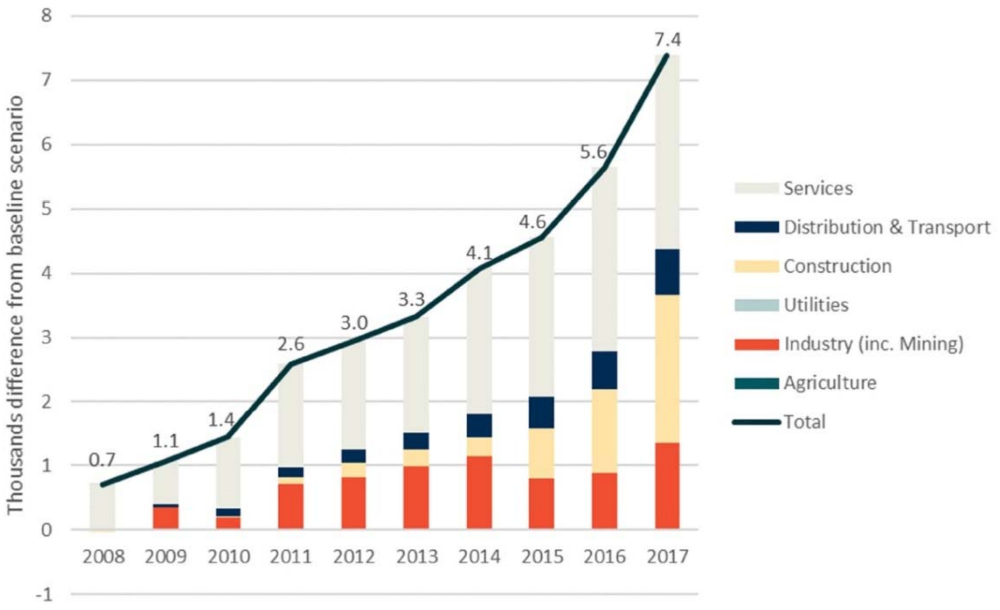
# Value for Money Study

- The E3ME economic analysis model was applied to calculate the impact of F4E spending in terms of Gross Value Added (GVA) and employment on the EU economy
- Data Collected based on **83 contractors** (30%)
- **Two** scenarios constructed, impacts measured relative to a baseline (=ITER's real impact from historical data)
  - **Gross** scenario: money spent on ITER since 2008 is subtracted (as if ITER money never spent at all)
  - **Net** scenario: money spent on ITER assumed instead spent elsewhere in EU economy (an "alternative spending" scenario)

# Value for Money: Gross impact scenario

- **Gross** impact is relative to a scenario in which the money spent on ITER was never spent at all

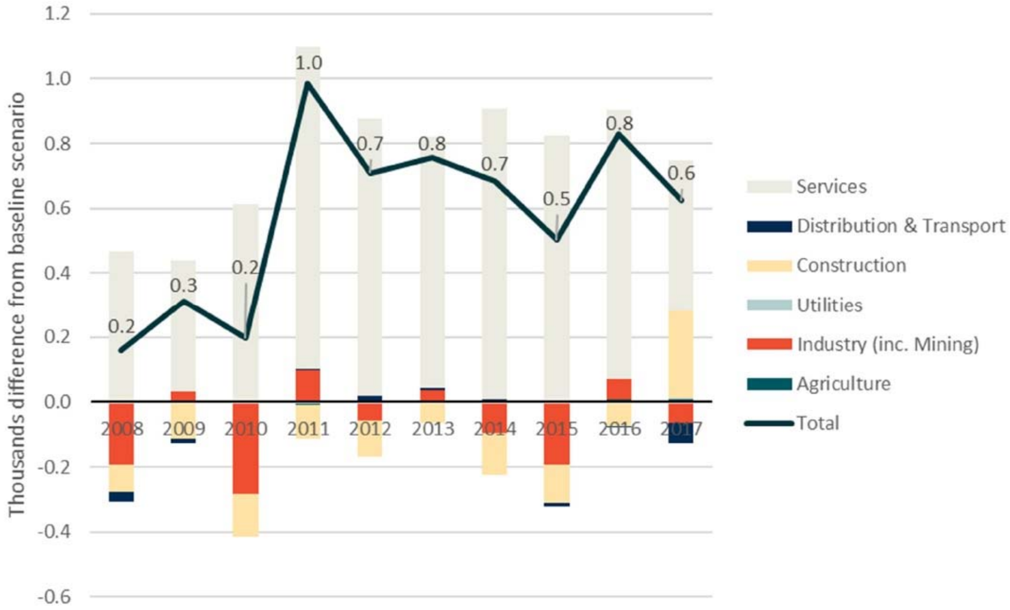
- Over the period 2008-2017, spending on ITER has produced:
  - almost EUR 4.8 billion in GVA
  - almost 34 000 jobyears



# Value for Money: Net impact scenario

- **Net** impact is a scenario in which the money spent on ITER was instead spent in other economic sectors

- Over the period 2008-2017, spending on ITER has produced:
  - EUR 132 million in GVA
  - 5 800 jobyears



European
Commission

# ITER Spin-offs

1/3 of firms involved have developed new cutting edge technologies as a direct result of their work on ITER

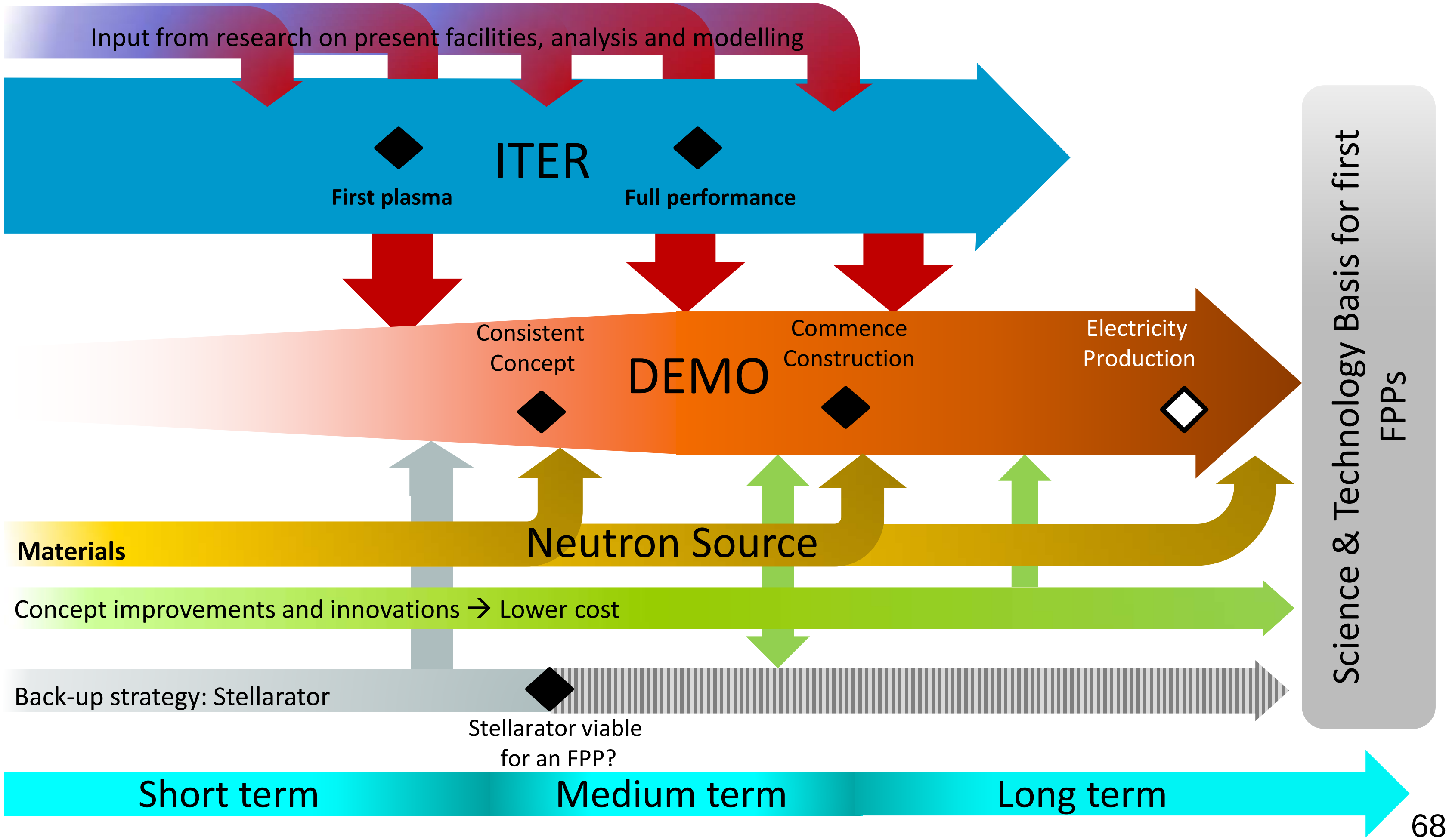
## Health

Superconducting cables employed for Medical Resonance Imaging by **Bruker**. Yearly turnover ~1 billion

## Materials sciences

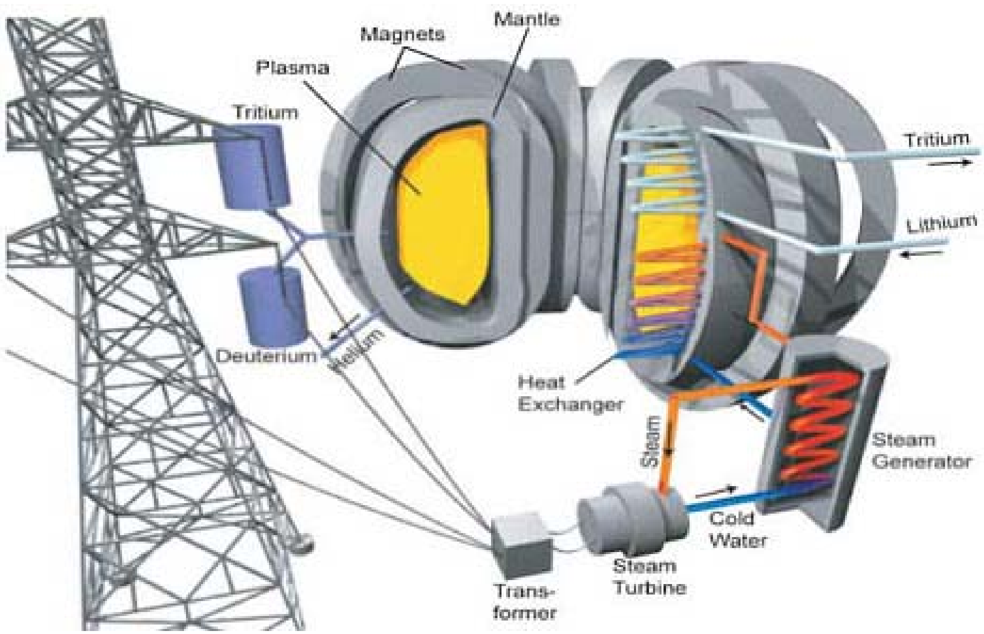
‘**3D Metal Forming**’ delivers sophisticated cockpit shapes to the aeronautics industry (Airbus) thanks to a pressing metal technique originally developed for ITER.

# The Fusion Roadmap



# Demonstration Power Plant - DEMO

*Industrial and Commercial exploitation by 2050*




Connected to the grid

Radius between 6 and 10 m

Power range between 500MW and 1500MW

# Opportunità per giovani

# EU and universities

## Towards a European Education Area

The goal is that, in Europe:

•spending **time abroad** to study and learn should be the standard;

•school and higher education **diplomas** should be recognised across the EU;

•knowing two **languages** in addition to one's mother tongue should become the norm;

•everyone should be able to access high quality education, irrespective of their socio-economic background; and

•people should have a strong sense of their **identity** as Europeans, of Europe's cultural heritage and its diversity.

# EU and universities

## European Student Card Initiative

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The European Student Card Initiative will enable every student to easily and safely identify and register themselves electronically at higher education institutions within the EU when moving abroad for studies, eliminating the need to complete on-site registration procedures and paper work.

The goal is to have, a full roll-out of this initiative in place by 2021 for all higher education institutions participating in the future Erasmus+ Programme (which will start in 2021), and make the card available to all students in Europe by 2025.

ITER https://www.iter.org/ jobs o associati IPA

Post doc ITER Monaco

F4E https://f4e.europa.eu/careers/

https://www.ifmif.org/ LIPAC Giappone

https://www.dtt-project.enea.it/ macchina DTT ENEA

**https://ec.europa.eu/stages/home_en**
**Blue Book Traineeship  5 mesi**
**Marzo od Ottobre**

**https://euraxess.ec.europa.eu/  sito con diverse posizioni**

European Commission

**EURES, the European Job Mobility Portal**
**https://ec.europa.eu/eures/public/homepage**

**European Parliament initiatives**
**https://www.thistimeimvoting.eu/**
**https://www.what-europe-does-for-me.eu/en/portal**
**http://www.europarl.europa.eu/at-your-service/en/stay-informed/citizens-app**

**Erasmus +**
**http://ec.europa.eu/programmes/erasmus-plus/opportunities/individuals/students/studying-abroad_en**

**European Youth Portal**
**https://europa.eu/youth/EU_en**

**EPSO: Traineeships EU Institutions**
**https://epso.europa.eu/job-opportunities/traineeships_en**