Euratom Research in Fission & Fusion
– what does the future hold?

Simon WEBSTER
HoU Fusion Association Agreements
Acting HoU ‘Fission’
DG Research & Innovation
European Commission
The future fission landscape

SET-Plan
low carbon energy technologies
+ESNII

Common Strategic Framework – support for R&D + innovation

Euratom programme
2009: EU Directive on nuclear safety
2011: EU Directive on management of radwaste
Participation in Euratom FP7 'Fission' Programme

4 Fission Calls:
FP7-Fission-2007, FP7-Fission-2008
FP7-Fission-2009, FP7-Fission-2010

EC Funding = €199.3M
Total Funding = €394M
Fusion – how do we get there?

organisation resources?

JET

ITER

DEMO

Power Plant

Future devices

Other devices

Technology development

Emerging technology

Theory & Modelling

resources?
The long term objective: Create the conditions for the construction of a fusion reactor for the generation of electricity

7th Euratom Framework Programme: “Developing the knowledge base for, and realising ITER as the major step towards, the creation of prototype reactors for power stations which are safe, sustainable, environmentally responsible, and economically viable”
The path towards DEMO

- Fusion Plasma Research
- Structural Material Dev.
- Structure Development
- Blanket technology
- Component Technology
- Test Blanket Module
- IFMIF
- Heavy Irradiation
- Tokamak DEMO Reactor
- ITER & DEMO Physics Support Activities
- ITER
- JET
- JT-60 SA

Fusion Engineering Research
The European Fusion Programme
The European Dimension/1

Contract of Association with each institute active in fusion research and the Commission

**EFDA (European Fusion Development Agreement)** between all the Associations together and the Commission

Activities of EFDA:
- Emerging technologies
- Research programme of JET
- International collaborations outside of F4E
- Education and training
The Framework Programme
(EC-FP7 2007-13, Euratom-FP7 2007-11)

- **Cooperation** – Collaborative Research (health, food, IT, nanotech, **energy**, environment, transport, space and security)
  - **Ideas** – Frontier Research € 7,510 M
  - **People** – Marie Curie Actions € 4,750 M
  - **Capacities** – Research Capacity € 4,097 M

  **Joint Research Centre**
  (nuclear and non-nuclear research) € 2,268 M

**Euratom (2007-2011):**
- **nuclear fission** (systems & safety, radwaste, RP) € 287 M
- **fusion energy** research* € 1,947 M

* with at least € 900 M for activities other than ITER construction
Distributed R&D 26 Associations in an Integrated Programme

- Euratom - CEA (1958) France
- Euratom – ENEA (1960) Italy (incl. Malta)
- Euratom - IPP (1961) Germany
- Euratom - FOM (1962) The Netherlands
- Euratom - FZJ (1962) Germany
- Euratom - Belgian State (1969) Belgium (incl. Luxembourg)
- Euratom - RISØ (1973) Denmark
- Euratom – UKAEA (1973) United Kingdom
- Euratom - VR (1976) Sweden
- Euratom - Conf. Suisse (1979) Switzerland
- Euratom - FZK (1982) Germany
- Euratom – CIEMAT (1986) Spain
- Euratom – IST (1990) Portugal

- Euratom - DCU (1996) Ireland
- Euratom - ÖAW (1996) Austria
- Euratom – MEdC (1999) Romania
- Euratom - IPPLM (2005) Poland
- Euratom – MHEST (2005) Slovenia
- Euratom – CU (2007) Slovakia
- Euratom – LEI (2007) Lithuania
JET, the Joint European Torus

- JET is closer in size to ITER than any other tokamak
- It has a plasma shape similar to ITER
- It is the only tokamak in the world able to operate with tritium
“F4E” - the European Joint undertaking for ITER and the development of fusion energy - Members are Euratom, represented by the Commission, the Euratom Member States + the countries Associated to Euratom (CH) in the field of fusion

F4E carries out the following tasks:

1. Delivers Europe’s obligations to the ITER Agreement;
2. Delivers Europe’s obligations to the Broader Approach Agreement;
3. Prepares and coordinates the programme of activities required for the timely construction of the first demonstration fusion reactor.
The ITER Project

- The largest energy research project in the World
- Essential part of the EU and world strategy for the development of fusion
- Scope: demonstrate the scientific and technical feasibility of fusion energy

Distribution of cost:
- EU: 45.46% (1/5th from France)
- Other ITER Partners: 9.09% each
Current status of the ITER and F4E project

- Contracts: ~€1000M committed in construction contracts Including
  - Magnet
  - Buildings
  - Vacuum Vessel

- Tokamak Pit ready for base concrete
- PF Coil manufacturing building
- ITER Office building
The “Fusion Industry Innovation Forum” formed in 2010:

- Define and implement, in conjunction with the research centres, a technology roadmap to a fusion power plant
- Define and implement a technology transfer programme
- Define and implement, in conjunction with the Commission and the fusion programme, skills development initiatives
- Provide input for consideration in the FP8 Commission proposals
- Report to the CCE-FU

The membership consists of:

- Sixteen Industrial Members on the FIIF Management Board, 2 Experts from the Associations, one expert from EFDA and one from Fusion for Energy.

Current activities:

- working with EFDA PPP&T department on pre-conceptual design definition.
- Drafting report on the implementation of a technology transfer programme in fusion research
- Reviewing the required future skills in industry
FIIF Management Board Members
### Fusion devices in the European programme

<table>
<thead>
<tr>
<th>Device</th>
<th>Type</th>
<th>Location</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>JET</td>
<td>Tokamak</td>
<td>Culham, UK</td>
<td>1983</td>
</tr>
<tr>
<td>ASDEX Upgrade</td>
<td>Tokamak</td>
<td>IPP Garching, Germany</td>
<td>1991</td>
</tr>
<tr>
<td>COMPASS</td>
<td>Tokamak</td>
<td>IPP.CR Prague, Czech Rep</td>
<td>2008 (transferred from UKAEA)</td>
</tr>
<tr>
<td>FTU</td>
<td>Tokamak</td>
<td>ENEA Frascati, Italy</td>
<td>1990</td>
</tr>
<tr>
<td>ISTTOK</td>
<td>Tokamak</td>
<td>IST Lisbon, Portugal</td>
<td>1992</td>
</tr>
<tr>
<td>MAST</td>
<td>Sph. Tokamak</td>
<td>UKAEA Culham, UK</td>
<td>1998</td>
</tr>
<tr>
<td>TCV</td>
<td>Tokamak</td>
<td>CRPP Lausanne, Switzerland</td>
<td>1992</td>
</tr>
<tr>
<td>TJ-II</td>
<td>Stellarator</td>
<td>CIEMAT Madrid, Spain</td>
<td>1997</td>
</tr>
<tr>
<td>TORE SUPRA</td>
<td>Tokamak</td>
<td>CEA Cadarache, France</td>
<td>1988</td>
</tr>
<tr>
<td>Wendelstein 7-X</td>
<td>Stellarator</td>
<td>IPP Greifswald, Germany</td>
<td>in construction</td>
</tr>
</tbody>
</table>
## ITER Parameters (2001 design)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor radius ($a$)</td>
<td>2.0 m</td>
<td>Installed additional heating and current drive ($P_{\text{add}}$)</td>
<td>73 MW</td>
</tr>
<tr>
<td>Major radius ($R_0$)</td>
<td>6.2 m</td>
<td>Plasma pulse length (inductive drive)</td>
<td>400 s</td>
</tr>
<tr>
<td>Plasma elongation ($\kappa$)</td>
<td>1.85</td>
<td>Average electron density ($\langle n_e \rangle$)</td>
<td>$1.1 \times 10^{20}$ m$^3$</td>
</tr>
<tr>
<td>Toroidal magnetic field ($B_T$) at $R_0$</td>
<td>5.3 T</td>
<td>Average ion temperature ($\langle T_e \rangle$)</td>
<td>8.9 keV</td>
</tr>
<tr>
<td>Nominal plasma current ($I_P$)</td>
<td>15 MA</td>
<td>Peak fusion power</td>
<td>500 MW</td>
</tr>
</tbody>
</table>
• Imminent / urgent actions
  – Agree 2-yr extension to Euratom FP7
  – Resolve ITER funding issue for 2012&13
  – Finalise Euratom proposal for programme post-2013 as part of CSF and the next Multi-annual Financial Framework
    • *Fission*: SET-Plan & Gen-IV, Fukushima?
    • *Fusion*: ITER, strategic roadmap, funding schemes, future of JET?

• Needed over medium / longer term
  – *Fission*: Increasing role of SNETP / IGDTP / MELODI & hopefully SET-Plan (strategic agendas for R&D, increased integration & cooperation, nuclear R&D fully part of policy on low-carbon technology)
  – *Fusion*: improved management of IO & F4E / construction of ITER / possible evolution of EFDA / extended operation of JET (D-T phase)
  – *Euratom*: increasing integration of the fission & fusion programmes in key areas (esp. materials) and with CSF instruments in general
Thank you for your attention!