# Call for Participation - EFDA Goal Oriented Training Programme.

## 1. Specific objectives of the action

The EFDA Goal Oriented Training Programme will involve early stage researcher teams that implement a structured training programme in the field of fusion energy research. The training programme will be carried out within the context of collaborative research between the partners in one of the areas specified below. It will provide a cohesive, but flexible framework for the training and professional development of researchers, especially in the early stages of their career.

Training programmes supported by this action will exploit the collaborative research partnership of the participants to the greatest extent possible. The programmes will not be academic oriented but shall provide the trainee with a practical experience, e.g. in industrial manufacturing activities or construction / enhancement / operation of major fusion facilities, typically combining general and specialist fusion energy training as well as interdisciplinary training (ex. Basic courses on Quality Assurance, CAD…) linked with the project. This programme aims at providing training for up to 40 researchers per year for a duration of up to three years in those areas of fusion energy research which are critical for the construction of ITER components and the realisation of fusion energy, and where a shortage of highly skilled professionals has been identified. For the present call for participation, which takes into accounts the training programmes already put in place in the previous calls, the following priority areas with targets for the number of trainees have been approved by the EFDA Steering Committee at its 48$^{th}$ meeting on 29 June 2011:

- **Materials technology for In-Vessel components**: about 5 trainees (or equivalent ppy/year).
- **Plasma facing components:** 3-4 trainees (or equivalent ppy/year).
- **Quality assurance**: about 4 trainees (or equivalent ppy/year).
- **Neutral Beam**: 3 trainees (or equivalent ppy/year).
- **Diagnostic Techniques (project engineers and engineering in extreme environment):** 5-8 trainees (or equivalent ppy/year).
- **Tokamak System Integration**: 5 trainees (or equivalent ppy/year).
- **Advanced Tokamak System Designs and Analysis Codes:** 1-3 trainees (or equivalent ppy/year)

Detailed objectives for each priority area are given in Annexes 1 to 7 of the present document.

Only the top ranking proposals evaluated above the threshold as defined in the evaluation criteria will be supported within the budget allocated. Therefore it could be that not all the priorities listed above are actually addressed.

## 2. Eligibility

See Guide for applicants.

## 3. Applicable evaluation criteria

See Guide for applicants.

## 4. Timetable of Implementation

Deadline for proposals: 23 November 2011

EFDA SC consultation: March 2012

Task placement: April 2012

## 5. Community contribution

The European Community will reimburse 40% of the “Personnel costs” and “Other costs” as defined in the Guide for Applicants; in addition “Mobility costs” of the researcher team will be eligible for reimbursement under the Mobility Agreement and according the general rules of this Agreement.

# Annex 1

# Fourth Goal Oriented Training Programme

# Priority Area

# Materials Technology for In-Vessel Components

**Objective**

The aim of this training is to prepare materials engineers for activities in the ITER project, the EU long-term fusion programme in Associations and for F4E.

In the specific case of this training, the objective is to develop expertise to fulfil future duties in the area of technology of structural materials foreseen for in-vessel components in DEMO and ITER Test Blanket Modules (TBMs). The training should i) provide basic principles and application of material selection criteria, fabrication and characterization of materials, assembling of components (joining); and ii) address issues of multi-layer or multi-material systems, i.e. structural materials in combination with coatings, protecting barriers or interfaces to corrosive environment.

To achieve this, it is foreseen that the training includes theoretical as wells as laboratory activities and educational tasks (attendance of courses and conferences).

**Scope**

This training in Materials Science and Technology will allow F4E and the Associates to hire experienced persons to carry out specific collaborative research projects assigned to them within the European activities for ITER, Broader Approach and DEMO.

**Training Activities**

The training will require the involvement of senior experts in material science and materials engineering with proven experience in the topics of the training. In the definition of the research project of the trainee, emphasis should be given to low activation Cr steels (conventional EUROFER or ODS variants).

The main activities should include elements from each of the following sub-items:

- Specific issues of structural materials in fusion, e.g.:
  - Material selection, tailoring and optimization of properties,
  - Failure mechanism under fusion specific environment (n-irradiation, corrosion).

(B) Practice in materials technology and testing, e.g.:

- Overview on different fabrication and joining processes including diffusion bonds,
- Qualification of materials and joints according to nuclear codes &standards,
- Fabrication and testing of multi-layer systems (W-armor, corrosion coatings, T-barriers).

(C) Modern tools for modelling and simulation of radiation effects and damage e.g.:

- Methods and tools to analyse and to simulate formation and evolution of defects ranging from micro-structural to macroscopic fracture (eg. DFT, kinetic Monte Carlo, Molecular Dynamics, Discrete Dislocation Dynamics),
- Advanced characterization methods including modern electron microscopy (SEM and/or TEM) and micro-mechanical testing (FIB, nano-indentation).

In addition to the research project activities in the laboratories of Associations, Universities or Industries, courses, discussion of publications in the open literature and

contributions to conferences shall complement the training program. Specific courses of management and follow-up of technical contracts as well as QA should be included.

# Annex 2

# Fourth Goal Oriented Training Programme

# Priority Area

# Plasma Facing Components

**Objective**
The aim of this training is to prepare engineers for activities to support the ITER project and the long-term fusion programme in Associations, Associates, Fusion for Energy and in the ITER Organization.
In the specific case of this training, the procurement system concerned is the First Wall, the armor material of which is Beryllium. The objective of the training is therefore to give the candidates the basic knowledge and experience needed to fulfill future duties for the procurement of the ITER First Wall.

**Scope**
This training will allow Fusion for Energy and the Associates to have experienced persons to carry out the specific tasks assigned to them within the European activities for ITER.

**Training Activities**
The main activities to be included in the training are:

- Theoretical courses on Beryllium properties and main applications,
- Current understanding of Beryllium hazards and overview of health and safety regulations applied for Beryllium,
- Applications to fusion activities including for example:
    - First Wall fabrication routes and joining techniques,
    - Design of Beryllium facilities including e.g. containment, ventilation requirements,
    - Requirements for protective equipments and health surveillance procedures,
    - Waste management including e.g. storage, decontamination and disposal requirements.

In addition, stages in laboratories, industries or institutions could complement the formation of the trainees.

Specific courses should be given on the management and follow-up of technical contracts as well as on QA, the basis for any kind of work and procurement.

# Annex 3

# Fourth Goal Oriented Training Programme

# Priority Area

# Quality Assurance

**Objective**
The aim of this training is to prepare engineers for activities to support the ITER project and the long-term fusion programme in Associations, Associates, Fusion for Energy and in the ITER Organization.
In the specific case of this training, the network objective is to develop among the Associates the knowledge of "Quality in Project Management" at a level adequate for them to participate into projects proposed by Fusion for Energy.

To achieve this, it is foreseen that the project will be organised in a QA Network structure developing Project Management knowledge through proven traditional practices that are widely applied

**Scope**
This training in Quality Project Management will allow Fusion for Energy and the Associates to have experienced persons to carry out the specific tasks assigned to them within the European activities for ITER.
The QA Network will provide the means for Associates to link up, in the context of well-defined projects proposed by Fusion for Energy (e.g. any Procurement Package from ITER or the Broader Approach), in order to implement an appropriate Project Management Plan (Quality Plan).

**Training Activities**
The main activities to be included in the training are:

- Training-through-project under the supervision of the experts in the domain;
- Quality requirements within Fusion for Energy projects;
- Provision of structured training courses (e.g. tutoring) that are available either locally or from another participant of the network;
- Organisation of courses to provide complementary training both within and outside the network. Topics of interest would include, for example quality certification, SADT (Structured Analysis and Design Technique), risk analysis, process maps, Earned Value Management (EVM) and language courses;
- Personal certification in PM

In addition, stages in laboratories, industries and institutions shall complement the formation of the trainees.

In order to be familiar with the tools used by Fusion for Energy to carry out its engineering activities, it is recommended that the training includes also introduction courses of CATIA V5 and Primavera.

# Annex 4

# Fourth Goal Oriented Training Programme

# Priority Area

# Neutral Beam

**Objective**
The aim of this training is to prepare engineers for activities to support the ITER project and the long-term fusion programme in Associations, Associates, Fusion for Energy and in the ITER Organization.
In the specific case of this training, the objective is to make available a number of engineers with expertise in the design, specification and procurement activities in the Negative Ion Based Neutral Beam system.

**Scope**
This training in the NB systems will allow Fusion for Energy and the Associates to have experienced persons to carry out the specific tasks assigned to them within the European activities for ITER.

**Training Activities**
The NB system is a complex system were multi-disciplinary aspects are integrated. In particular, the following fields of expertise are needed:

- mechanical engineering in general
- assembly procedures
- high heat flux components
- ultra high voltage technologies
- cryo-system technology
- vacuum technology
- remote handling
- structural and thermo-mechanical analysis (e.g. with ANSYS);
- supervision of drawing office and familiarity with the CATIA system

In addition, stages in laboratories, industries and institutions and, as applicable, participation to specific courses shall complement the formation of the trainees.
There are also important aspects related to electrical engineering which will be considered under a separated training.

The NB procurement is largely based on build-to-print specifications which still require very substantial R&D to be carried out in the Associates and, in particular, in the existing test facilities and in the new, planned, full scale test facility to be established in Padua. The industry is in fact involved mainly in the construction of components, while the detailed design, analysis and drawings will be produced by the cooperation between F4E, ITER IO and the Associations involved in the R&D with little direct involvement of the industry.

It is therefore envisaged that the large part of the training will be carried within the Associates active in the field and, in a much more limited extend, in F4E.

The main activities to be included in the training are:

- participation in the design, R&D and procurement activities in the Associates, and as applicable in F4E, under supervision by senior engineers
- participation in specialist courses in the areas of interest.
- specific training and courses in QA procedures
- training and courses in planning, including the use of related software such Primavera
- courses and/or seminar on the Procurement Regulations applicable in F4E. This will require the provision of such courses by experienced Procurement Officers in F4E.

In order to be familiar with the tools used by Fusion for Energy to carry out its engineering activities, it is recommended that the training includes also courses of ANSYS and CATIA V5, or other main applicable software tools.

# Annex 5

# Fourth Goal Oriented Training Programme

# Priority Area

# Diagnostiques techniques

**Objective:**
The development of diagnostic components for ITER and future fusion reactors is very challenging due to the extreme nature of the ITER environment, with nuclear; thermal; electromagnetic; and particle loads in high vacuum and electrically noisy conditions. Diagnostic engineering on present machines only prepares for a small subset of these challenges.
The objective of this training is to develop project engineers with a broad spectrum of knowledge, spanning the whole range of engineering issues required for the design of diagnostic systems for ITER.

**Training Activities:**

- Overview of plasma diagnostics (optical, microwave, spectroscopic, fusion-product, magnetics, other), diagnostic needs (electrical, calibration, alignment, positioning) and engineering aspects;
- Engineering in a nuclear environment (legal aspects, licensing, applicable codes and standards, ALARA, occupational radiation exposure);
- Electromagnetic loads in a tokamak;
- Thermal loads (radiation, nuclear);
- Cooling circuits and thermo-hydraulic analysis;
- Vacuum (vacuum systems, materials, tritium/safety, beryllium, electrical and mechanical feedthroughs, movement in vacuum, windows, outgassing);
- Neutronics analysis (codes, streaming, heating, activation);
- Nuclear effects in structural materials, welds, functional materials (e.g. transmission and insulating materials) and diagnostic components;
- Vibration effects;
- Particle loads (chemical and physical sputtering, erosion, deposition);
- Metrology for accurate positioning;
- Remote handling (handling, tooling, electrical connectors); and
- Electromagnetic and other noise (shielding, cables, connectors)

The emphasis will be on gaining understanding, but should include training on the use of specific analysis software in some of the areas listed above. The trainees will consolidate the training by stages with diagnostic groups in the Associates that are doing work on ITER. Stages in laboratories, industries or institutions could complement the formation of the trainees (e.g. Nuclear or Space industries/institutions).
In addition, it is foreseen that trainees are given courses in “transverse” subjects, such as QA, project management, industrial follow-up and RAMI.

# Annex 6

# Fourth Goal Oriented Training Programme

# Priority Area

# Tokamak Systems Integration

## OBJECTIVE

The aim of this training is to prepare engineers for activities to support the ITER project and the long-term fusion programme within the Associates, in Fusion for Energy and in the ITER Organisation.
In the specific case of this training, the objective is to develop system engineers with experience in integration and commissioning of tokamak systems.
To achieve this, it is foreseen that the training combine theoretical lessons with the involvement in the development and commissioning of tokamak systems.

## SCOPE

This training will allow the European fusion programme to have experienced people to carry out the integration, assembly and commissioning of tokamak systems within ITER.

## TRAINING ACTIVITIES

The activities to be included in the training are one or more of the following

- Participate in the life cycle (design to commissioning) of the main components in a tokamak system;
- Get a detailed look at the assembly plan of the existing machines, with special care on the assembly phases with their mechanical requirements as well as the use of special tools for the study of assembly tolerances and the methods of determining special reference points for components alignment;
- Advanced training on the CATIA system to prepare and manage Digital Mock-ups. Use of specific tools for kinematics and assembly (i.e. DELMIA):
- Participate to the restart activities of an existing tokamak
    - Be involved in the planning
    - Be trained in one of the control room main functions
    - Be involved in the commissioning of a tokamak system

# Annex 7

# Fourth Goal Oriented Training Programme

# Priority Area

# Development and Application of Advanced Tokamak System Design and Analysis Codes for the Conceptual Designs of a Demonstration Fusion Reactor (DEMO)

## Objectives of the training

With the construction of ITER which is well underway there is now renewed interest turning to the modelling and conceptual design of a Demonstration Fusion Reactor (DEMO) which, in the European Strategy, is the step to follow towards the development of fusion power. The challenge for young engineers will be in particular to contribute to the development and application of robust and validated design system codes to be used to carry out conceptual design simulations of DEMO, based primarily on tokamak configurations and associated performance and cost optimisations (robust relative to uncertainties) based on selected plasma and engineering input parameters.

## Contents of the training

The trainee will work with senior fusion development engineers and scientists in engineering teams to be established in Associations, and especially competent on:

- tokamak design and system integration;
- tokamak operation;
- structural, thermal-mechanical and electro-magnetic analysis;
- heat extraction and thermal-hydraulic analysis;
- neutron transport, shielding and radiation protection design.

A good practice of advanced numerical analysis methods and use of advanced computational tools and methodologies is required.

In addition, the main activities to be included in this training are:

- Formal courses on fusion engineering and applied plasma physics, such as those offered every year at JET or in other leading EU associations;
- Introduction courses or equivalent practical experience in application of design tools (especially CAD systems, ANSYS, etc.).
- Familiarization with use of integrated tokamak system design and modelling tools and direct application to contribute to DEMO conceptual design studies. In this context, the main activities required to simulate tokamak systems and subsystems are expected to include:

1. **Design optimisation studies**: *to obtain minimum cost machine(s) with clearly defined design criteria and operation requirements and coupled physics, engineering and costing constrains.*

2. **Cost –vs.-performance sensitivity studies**: to *perform cost-v-performance sensitivity studies around the design point.*

3. **Operational flexibility*:*** *to assess operational flexibility of final design point using the capabilities of the system code.*

4. **Design option trade-offs:** *to self consistently compare and contrast design options (e.g., steady-state vs. pulsed design configurations, etc.) under the same physics, engineering and cost assumptions.*