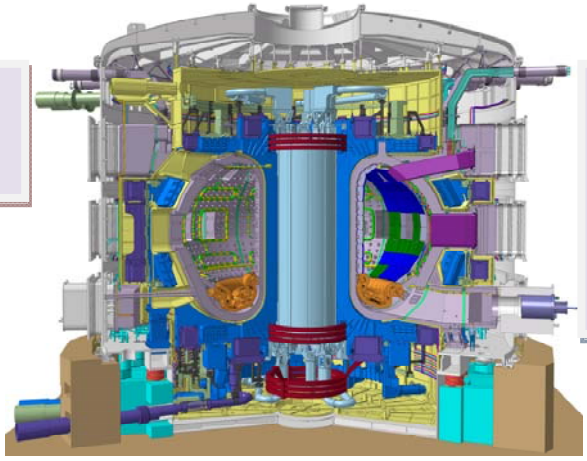
Asssociation EURATOM-ÖAW

FINAL REPORT
2007-2013

Austrian Fusion RTD Activities

Integrated Tokamak Modelling
Universität Innsbruck
Technische Universität Wien

PlasmaWall Interaction
Technische Universität Wien
Universität Innsbruck



Plasma turbulence, ELMs, fast particles, transport measurements, RMP effects, stellarator modelling
Universität Innsbruck
Technische Universität Wien
Technische Universität Graz

Graph: ITER cutaway, source: http://www.iter.org/

Power Plant Physics and Technology:
Materials, high-temperature superconductors
Socio-economic studies
Erich-Schmid-Institut für Materialwissenschaft/ ÖAW
Technische Universität Wien
Research Studio Salzburg

Association EURATOM-ÖAW

FINAL REPORT 2007-2013

Austrian Fusion RTD Activities

Vienna
October 2014

The Final Report of the Association EURATOM-ÖAW describes the work performed under the Contract of Association between EURATOM and ÖAW from 2007 to 2013.

Compiled by Monika Fischer

The work, supported by the European Commission under Contract of Association no. FU07/CT/2007/00066 , was carried out within the framework of the European Fusion Development Agreement (EFDA). The views and opinions expressed herein do not necessarily reflect those of the European Commission.

This brochure presents a summary of the work performed under the Contract of Association between EURATOM and ÖAW from 2007 to 2013. The Annual Reports 2007 to 2013 are included on the enclosed CD-Rom.

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Attachments:
Annual Reports 2007-2013 included on the enclosed CD

SUMMARY OF WORK PERFORMED UNDER CONTRACT OF ASSOCIATION No. FU07/CT/2007/00066

Introduction

The first Contract of Association between the European Commission and the Austrian Academy of Sciences was signed in November 1996, after Austria's accession to the European Union in 1995. From this date onwards the Austrian Fusion Research Programme was aligned to the priorities set within the European Fusion Programme.

Austria does not have a facility dedicated to fusion research. The Association EURATOM-ÖAW therefore consisted of a network of scientific contributors at universities, the Austrian Academy of Sciences and other research institutions. Training and education of young researchers in the fields of fusion research and technology has been a predominant goal within this network, and frequent use was made of Staff Mobility to promote visits of researchers to major European fusion facilities such as JET and ASDEX Upgrade. Efforts to keep young researchers in the programme and to enable the continuation and completion of PhD theses and other studies were supported by the continuous framework of the Contract of Association until the end of 2013 and a special national programme of the Commission for the Coordination of Fusion Research in Austria (KKKÖ) at the Austrian Academy of Sciences.

In November 2006 the ITER Agreement was signed. The European Union's Joint Undertaking for ITER and the Development of Fusion Energy (Fusion for Energy – F4E) was created in April 2007 with the objectives of providing Europe's contribution to ITER and managing the European contribution to the Broader Approach. From 2007 onwards technology areas directly related to ITER were transferred to the responsibility of F4E. The European Fusion Development Agreement (EFDA) was amended to provide a robust co-ordinating infrastructure to focus the activities of the EURATOM Associations to the priorities defined in annual work programmes.

In light of the above, the year 2007 was characterized by the transition to the amended EFDA Agreement. Research groups of the Association EURATOM-ÖAW completed a number of technology tasks which had been started under EFDA in the preceding years. The expertise developed by executing some these tasks led to follow-on contracts with ITER and F4E (irradiation effects on insulating materials, nuclear data, ITER scenario modelling).

In the period from 2008 to 2013, research performed under the Contract of Association was streamlined along the annual work programmes of EFDA and focussed on the core competences Integrated Tokamak Modelling (ITM), Plasma Wall Interaction (PWI), Heating and Current Drive (HCD), Magneto-hydrodynamics (MHD) and Transport (TRA, from 2012 under the responsibility of the EFDA Department for ITER Physics) as well as Materials (MAT), High-Temperature Superconductors (HTS) and Socio-Economic Studies (SERF, from 2012 under the responsibility of the EFDA Power Plant Physics and Technology Department). A small number of researchers participated in each of the JET Campaigns. Figure 1 below shows the average annual distribution of research over the fields listed above.

In December 2012, the Association EURATOM-ÖAW was evaluated by an independent panel of experts who confirmed the relevance and competitiveness of the Association's competencies, also with a view to future participation in Horizon 2020.

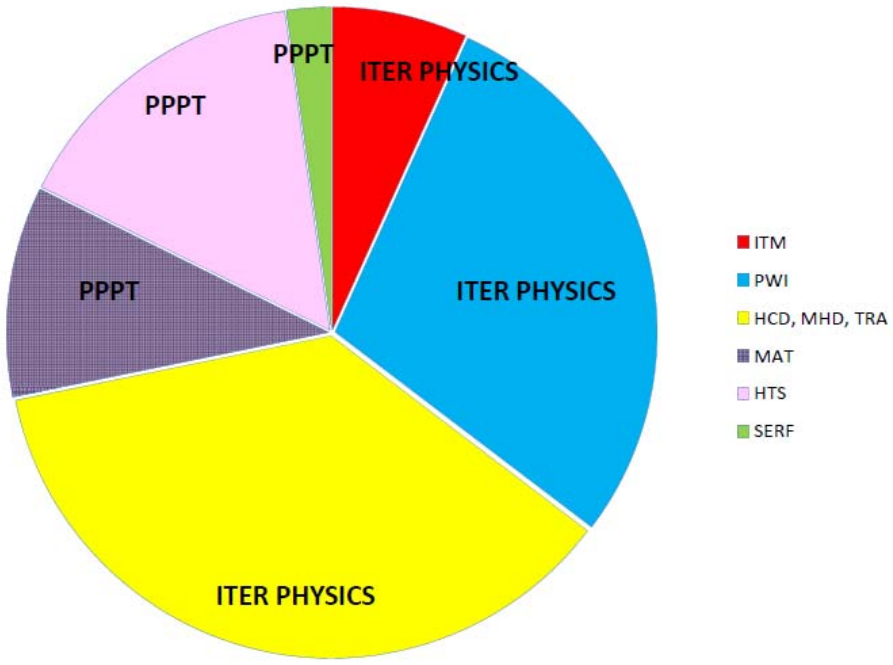


Figure 1. Average annual participation in EFDA task areas, 2008-2013

The Heads of Research Unit of the Association during FP7 were Univ. Prof. Dr. Harald W. Weber from November 2006 to December 2012 and Univ. Prof. Dr. Friedrich Aumayr from January to December 2013. On average, Steering committee meetings were held twice a year. The Association's research activities were presented by the contributing research groups at Association Days organized once a year. Invited guests came from EFDA, the European Commission or collaborating laboratories. The annual Association Days were designed as a forum for information exchange and new incentives to promote scientific collaborations.

Statistical data

Average number of participating institutions / year	5
Average total number of staff members / year (all categories)	90
of which:	
Senior researchers	14
Post-Docs	17
PhD students	24
Others	35
Average number of ppy / year	40
Average number of refereed articles in scientific journals / year	43

Overview on research groups and scientific topics, 2007-2013

The activities below are grouped according to the task areas shown in figure 1 above. For detailed reports on the activities listed below please refer to the Annual Reports 2007-2013.

Coordinated activities on ITER Physics

Integrated Tokamak Modelling (ITM)

S. Kuhn, N. Jelic, D. Tskhakaya jun., D.D. Tskahakya sen. et al. (Institut für Theoretische Physik, Universität Innsbruck)

Integrated modelling of pedestal formation, ELM generation and impurity transport (S. Kuhn, D. Takhakaya jun., D. Tskhakaya sen. et al.)

Improved boundary conditions for SOL simulation codes (S. Kuhn, N. Jelic, D.D. Tskhakaya sen. et al.)

Development of kinetic particle-in-cell (PIC) codes capable of simulating the scrape-off layer (SOL) of ITER (BIT 1 and 2, D. Tskhakaya jun.)

Participation in IMP3 task management (D. Tskhakaya jun.)

Collaborations: IPP Garching, JET, MESCS

K. Schöpf, T. Gassner, V. Goloborod'ko, E. Reiter, V. Yavorskij (Institut für Theoretische Physik, Universität Innsbruck)

Predictive modelling of fusion alpha and neutron-beam injection (NBI) ion behaviour in ITER

Modelling of fast-ion behaviour in tokamak plasmas to explain specific transport mechanisms as well as loss measurements of charged fusion products and injected ions in JET

Development of fast particle codes (e.g. coupled HAGIS-FIDIT code)

Collaborations: JET, IPP Garching

F. Köchl (Atominstitut, Technische Universität Wien)

ITER scenario modelling

Collaborations: CEA, JET

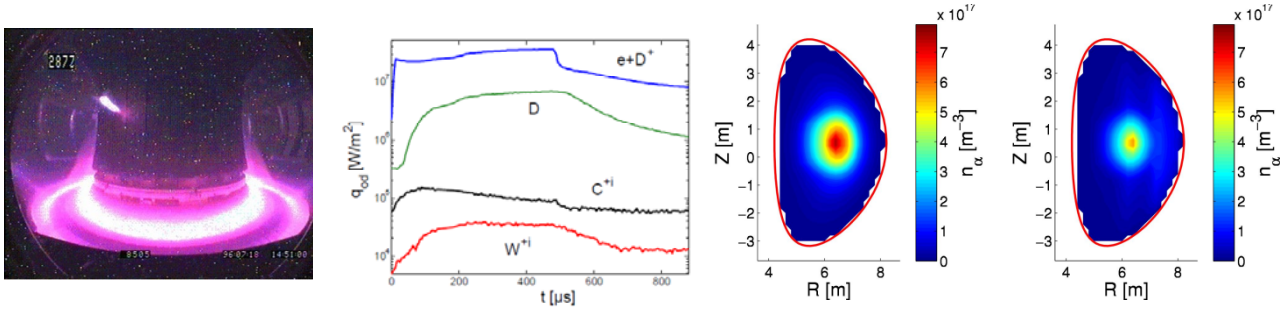


Figure 2, from left to right: pellet in flight (white spot near the left upper corner). In order to clarify the effects of pellets on the behaviour of edge-localized modes (ELMs), MHD stability codes were coupled with pellet injection models. F. Köchl participated in this work in collaboration with JET and CEA. Source of graph: http://www.efda.org/jet; plasma, neutral and impurity power loads to the JET outer divertor during a 300 kJ ELM (D. Tskhakaya et al.); initial fast alpha density profile corresponding to a stationary alpha distribution calculated in FIDIT; redistributed fast alpha density delivered by HAGIS considering particle-wave interaction with 15 toroidicity-induced Alfvén Eigenmodes (K. Schöpf et al.)

F. Aumayr, K. Igenbergs, A. Veiter et al. (Institut für Angewandte Physik, Technische Universität Wien)

P. Scheier, S. Denifl, A. Keim, S. Zöttl et al. (Institut für Ionenphysik und Angewandte Physik, Universität Innsbruck)

Delivery of atomic data (cross sections for charge transfer, excitation and ionization) to the ITM-AMNS data base

Plasma-Wall Interaction (PWI)

F. Aumayr, K. Dobes, A. Golczewski, E. Gruber, K. Igenbergs, G. Kowarik, R. Ritter et al. (Institut für Angewandte Physik, Technische Universität Wien)

Development of the PWI basis in support of integrated high-Z scenarios for ITER

Determination of total surface erosion yields by means of a Quartz Crystal Micro-balance (QCM) system

Study of deuterium retention in tungsten by means of the QCM system

Investigation of the formation and re-erosion dynamics of ITER-relevant mixed materials, using the QCM setup

Collaborations: IPP Garching

P. Scheier, P. Bartl, M. Daxner, S. Denifl, M. Harnisch, A. Keim, T.D. Märk, M. Probst, S. Zöttl et al. (Institut für Ionenphysik und Angewandte Physik, Universität Innsbruck)

Ion-surface collisions of small hydrocarbon molecules

Electron and proton impact excitation/ionisation reactions with plasma edge atoms, molecules and ions

Chemical erosion under ITER-relevant conditions

Collaborations: CU Bratislava, IPP Garching

M. Probst, S. Huber, A. Kaiser, A. Mauracher et al. (Institut für Ionenphysik und Angewandte Physik, Universität Innsbruck)

Molecular dynamics simulation of carbon erosion

Material mixing under ITER-relevant conditions

Collaborations: IPP Garching

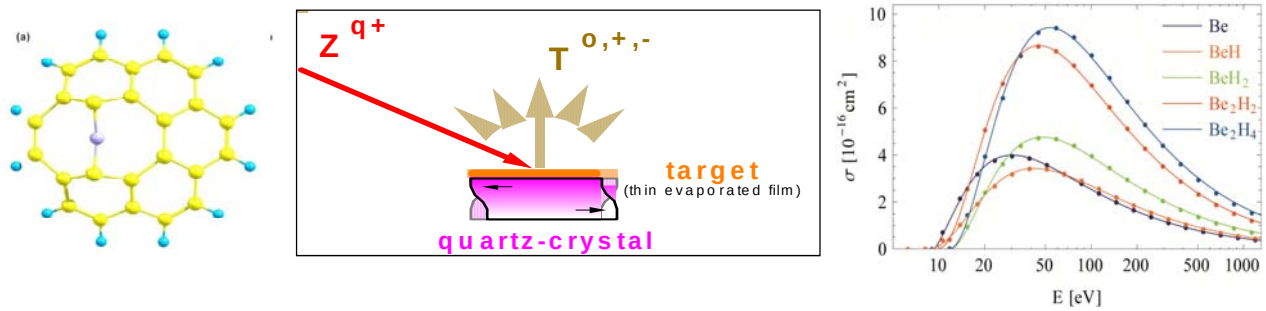


Figure 3, from left to right: sample of molecular dynamics simulation: deformation of coronene due to permeation of Be at bridge site, obtained with the PBE0 method (M. Probst et al.); quartz crystal setup for edge plasma diagnostics used by F. Aumayr et al.; electron impact cross sections of several Be-hydrides (P. Scheier, M. Probst et al.)

Heating and Current Drive (HCD), Magneto-hydrodynamics (MHD) and Transport (TRA)

W. Kernbichler, K. Allmeier, M. Heyn, G. Kapper, S. Kasilov, P. Leitner, A. Martitsch, M. Mulec, V. Nyemov et al. (Institut für Theoretische Physik / Computational Physics, Technische Universität Graz)

Modelling of neoclassical transport in stellarators

Effects of resonant magnetic field perturbations (RMPs) produced with a special coil set (possible ELM mitigation tool for ITER)

Numerical evaluation of toroidal viscosity and evolution of equilibrium plasma parameters

Collaborations: IPP Garching and Greifswald, JET

K. Schöpf, V. Goloborod'ko, V. Yavorskij (Institut für Theoretische Physik, Universität Innsbruck)

Evaluation of alpha particle effects on the plasma in steady-state operation

Alpha particle simulation experiments

Collaborations: JET

F. Aumayr, F. Laggner, M. Willensdorfer (Institut für Angewandte Physik, Technische Universität Wien)

Fluctuation measurements with the neutral Li beam at ASDEX Upgrade in the edge transport barrier region and the adjacent scrape off layer in L-mode, during LH transitions and in the following period up to the first ELM

Characterization of edge pedestal density with the upgraded Li-beam diagnostics at ASDEX Upgrade

Collaborations: IPP Garching, HAS

R. Schrittwieser, C. Ionita-Schrittwieser, C. Maszl, F. Mehlmann, S. Costea et al. (Institut für Ionenphysik und Angewandte Physik, Universität Innsbruck)

Electrostatic plasma-turbulence measurements by means of specialised plasma probes

Collection of data on plasma phenomena, especially ELMS (short, recurrent instabilities of the edge plasma) by various methods (plasma probes, specifically designed probe systems, magnetic coils), based on experiments in JET, ASDEX Upgrade and COMPASS

Collaborations: IPP Garching (ASDEX Upgrade), Consortio RFX, MHEST, IPP.CR, JET and Risø (data evaluation).

Figure 4, from left to right: Poincare plot of the magnetic field with resonant magnetic perturbation (RMP) shielding (the red line shows the safety factor; W. Kernbichler et. al.); ball-point-pen probe head used in the COMPASS mid-plane by R- Schrittwieser et al; modelling the effects of RMP fields on turbulence and ELMs (A. Kendl et al.)

A. Kendl, F. Gennrich, M. Held, C. Knapp, S. Konzett, O. Meyer J. Peer, J. Seebacher, M. Wiesenberger et al. (Institut für Ionenphysik und Angewandte Physik, Universität Innsbruck)

Participation in the project "Integration of transport and MHD codes at JET" (J. Seebacher)

Simulation of experiments in ASDEX Upgrade with the kinetic trace ion module TRACE for the Monte Carlo code EIRENE

Non-linear gyrofluid simulations of plasma edge turbulence and edge localized ideal ballooning modes using the GEMR code (by B.D. Scott, IPP Garching)

Collaborations: FZ Jülich, IPP Garching

Contributions to Power Plant Physics and Technology (PPPT)

Materials (MAT)

Two tasks of the previous Underlying Technology Programme were completed in 2007. Investigations on these topics were discontinued, mainly due to lack of resources:

H. Rauch, H. Tatlisu et al. (Atominstitut, Technische Universität Wien)

Structural investigation of SiC_fSiC components

H. Störi, C. Tomastik et al. (Institut für Allgemeine Physik[1], Technische Universität Wien)

Transport of impurities in beryllium

Work continued throughout the duration of the Contract of Association:

R. Pippan, P. Kutlesa, S. Wurster (Erich-Schmid-Institut für Materialwissenschaft at ÖAW

Mechanical characterization of tungsten alloys and other high heat-flux materials

Experiments to improve the ductility of tungsten alloys

Collaborations: KIT

High-Temperature Superconductors (HTS)

H.W. Weber, J. Emhofer, M. Eisterer, T. Baumgartner, J. Hecher, V. Mishev, R. Prokopec, F. Sauerzopf, M. Zehetmayer (Atominstitut, Technische Universität Wien)

Characterization of high-temperature superconductors for fusion magnets and monitoring of industrial development

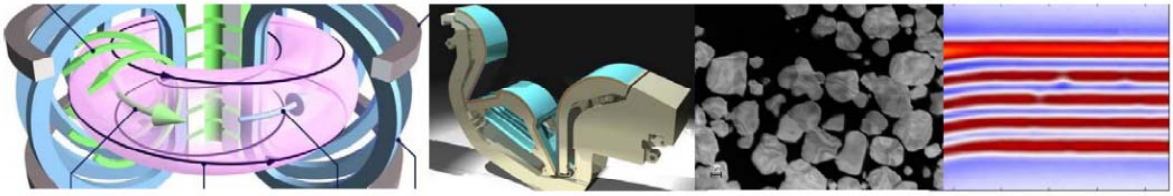


Figure 5, from left to right: the tokamak principle: plasma confinement by magnetic fields generated by toroidal field coils (source: http://www.efda.org; ITER divertor cassette: the ITER divertor is installed to constantly remove the helium "ash" from the plasma. (source: http://www.iter.org); optimization of tungsten alloys by changing the micro-structure (source: Erich-Schmid-Institut für Materialwissenschaft, ÖAW); test image of superconducting tape developed by industry (source: Atominstitut, Technische Universität Wien).

[1] Re-named „Institut für Angewandte Physik" as of September 2009.

Socio-Economic Research on Fusion (SERF)

M. Baumann et al. (Institut für Theoretische Physik / Computational Physics, Technische Universität Graz, 2007-2009); M. Biberacher et al. (Research Studio Salzburg, 2010-2013)

Development of the EFDA TIMES model

Energy scenario modelling

Collaborations: CIEMAT, IPP Garching

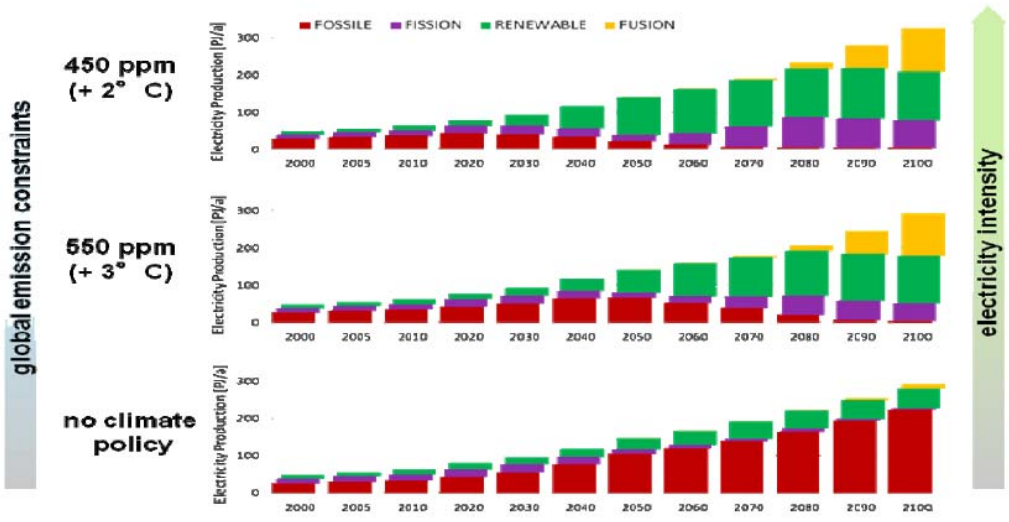


Figure 6. Fusion as a relevant contributor to sustainable energy pathways, depending on climate policy (reduction of CO_2 emissions); scenario generated with the EFDA Times Model

Competencies acquired for follow-on contracts with ITER and F4E

H.W. Weber, M. Eisterer, H. Fillunger, K. Humer, R. Maix, R. Prokopec (Atominstitut, Technische Universität Wien)

Irradiation testing of insulation materials for the ITER magnets

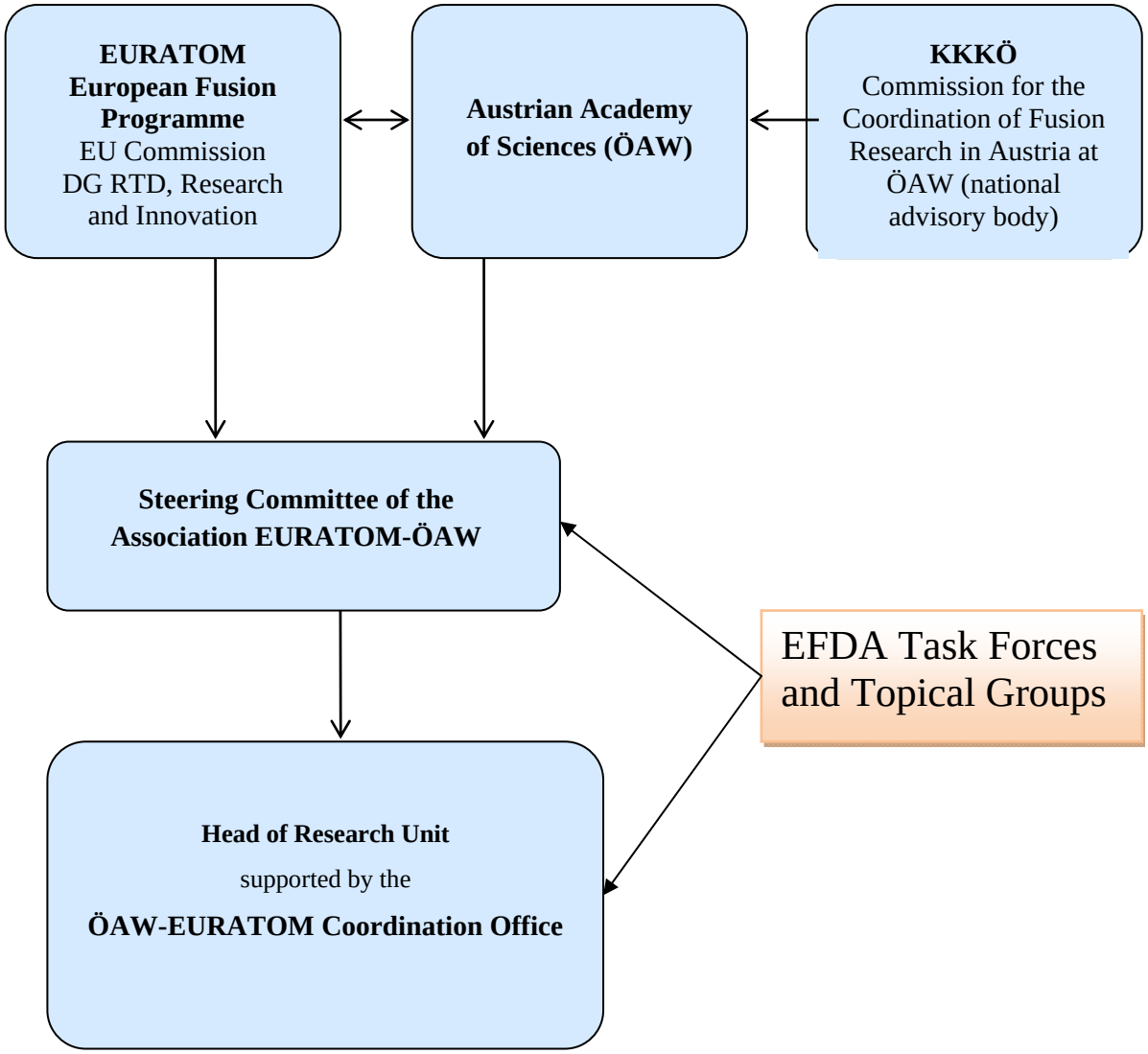
H. Leeb et al. (Atominstitut, Technische Universität Wien)

Nuclear data

F. Köchl (Atominstitut, Technische Universität Wien)

ITER scenario modelling

ASSOCIATION EURATOM-ÖAW: MANAGEMENT STRUCTURE



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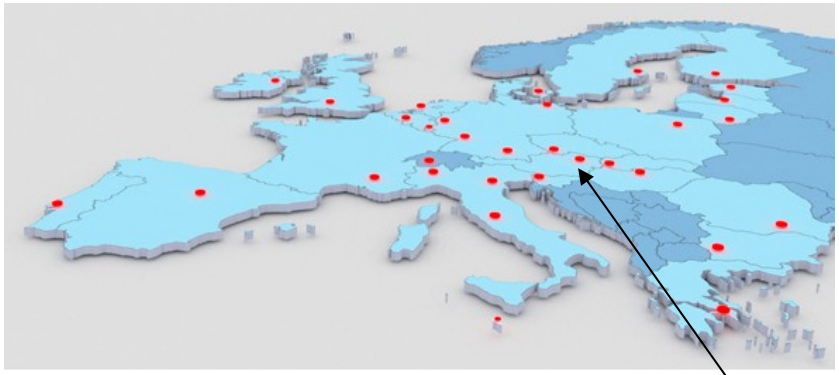
Back cover:
The European Fusion Development Agreement:
Catalysing collaboration in European fusion research
The Association EURATOM-ÖAW:
Coordinating fusion research at several research institutions in Austria

Graphs: Europe: https://www.euro-Fusion.org/eurofusion/organisation/research-units/
Austria: Association EURATOM-ÖAW

EFDA



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