IRFM - Institut de recherche sur la fusion par confinement magnétique

Rapport Hcéres

HCERES

High Council for the Evaluation of Research and Higher Education

Department of Research Evaluation

report on research unit:

Institute for Magnetic Fusion Research

IRFM

Under the supervision of the following institutions and research bodies:

Commissariat à l'Énergie Atomique et aux Énergies Alternatives – CEA

Evaluation Campaign 2016-2017 (Group C)

HCERES

High Council for the Evaluation of Research and Higher Education

Department of Research Evaluation

In the name of HCERES,[1]

Michel Cosnard, president

In the name of the experts committee,[2]

Sylvie JACQUEMOT, chairman of the committee

Under the decree No.2014-1365 dated 14 november 2014,

[1] The president of HCERES "countersigns the evaluation reports set up by the experts committees and signed by their chairman." (Article 8, paragraph 5)

[2] The evaluation reports "are signed by the chairman of the expert committee". (Article 11, paragraph 2)

Evaluation report

This report is the sole result of evaluation by the expert committee, the composition of which is specified below.

The assessments contained herein are the expression of an independent and collegial reviewing by the committee.

Unit name:	Institute for Magnetic Fusion Research
Unit acronym:	IRFM
Label requested:	Unité Propre CEA / Direction de la Recherche Fondamentale
Current number:	-
Name of Director (2016-2017):	Mr Alain BÉCOULET
Name of Project Leader (2018-2022):	Mr Alain BÉCOULET

Expert committee members

Chair:	Ms Sylvie JACQUEMOT, CEA
Experts:	Mr Serge BOUFFARD, ENSI Caen
	Mr Martin COX, Culham Centre for Fusion Energy (CCFE), United Kingdom
	Mr François DEBRAY, CNRS
	Mr Carlos HIDALGO VERA, Centro de Investigaciones Energéticas, MedioAmbientales y Tecnológicas (CIEMAT), Spain
	Mr Volker NAULIN, Danmarks Tekniske Universitet/Fysikvej (DTU/Physics), Denmark
	Mr Rudolf NEU, Max-Planck-Institute for Plasma Physics (IPP), Germany
	Mr Felix Ignacio PARRA DIAZ, Oxford University, United Kingdom

Scientific delegate representing the HCERES:

Mr Christian BORDAS

Institute for Magnetic Fusion Research, IRFM, CEA, Mr Alain BÉCOULET

Representative of supervising institutions and bodies:

Mr Philippe CHOMAZ, CEA/DRF

Head of Doctoral School:

Mr Conrad BECKER, Doctoral School n°352, « Physique et Sciences de la Matière »

1 • Introduction

History and geographical location of the unit

The Institute for Magnetic Fusion Research (IRFM) is one of the fifteen research institutes and laboratories of the Fundamental Research Division (DRF) of the French Alternative Energies and Atomic Energy Commission (CEA). Located south of France in the village of Saint-Paul-lez-Durance (Bouches-du-Rhône), it is hosted by the CEA Cadarache Center since the late 80's, following construction at the site of the TORE SUPRA tokamak and centralization of the French researches on magnetic fusion energy (MFE), until then mainly conducted on the TFR machine at the CEN Fontenay-aux-Roses and on the PETULA tokamak at the CEN Grenoble.

These studies were included in the EURATOM fusion program; IRFM was the Head of the EURATOM-CEA association till 2013 and, since then, is the French signatory of the European Consortium for the Development of Fusion Energy (EUROfusion Consortium); it stands out thus as an essential intermediary between the European Commission and the French MFE academic community, represented since 2007 by the Research Federation n. 3029 on "Magnetic Confinement Fusion – ITER" (FR-FCM). The international decision in 2005 to build the International Thermonuclear Experimental Reactor (ITER) in Cadarache recognized the French history of excellence in plasma physics and in tokamak technology. It reinforced the international presence of the Institute, now a key partner of the project.

Management team

The Institute was reorganized in January 2016 in order to cope with the challenges posed by an evolving environment whose complex and layered coordination structure [ITER Organization (IO), Fusion for Energy (F4E), European Fusion Development Agreement (EFDA) and since 2014 EUROfusion, FR-FCM] requires simplified interfaces as well as well-identified and properly distributed responsibilities.

Three Departments, of roughly equal weight in terms of staff (~100 persons), are now handling the scientific and technological activities of the Institute: Fusion Plasma Physics (SPPF, led by Mr Frédéric IMBEAUX), Tokamak Operation and Piloting (STEP, led by Mr Sylvain BRÉMOND) and Engineering & Projects (SI2P, led by Mr Philippe MAGAUD), each of them being organized – per research field or per function - around 5 laboratories. Only 7 of these 15 laboratories are conducting research activities and are therefore subjects to HCERES evaluation. The other laboratories are conducting technical support activities.

IRFM is managed since December 2011 by Mr Alain BÉCOULET, assisted by Mr André GROSMAN. He rests on a directorate level (direction), structured in 4 units, in charge of the functional and programmatic management as well as of all the communication and safety/environment matters.

HCERES nomenclature

Scientific areas: Sciences & technologies - Physics (ST2) & Engineering (ST5)
Applicative areas: Nuclear Energy

Scientific domains

Addressing the energy/climate challenges of the 21st century by the development of a reduced carbon energy portfolio, from renewable to nuclear energies, is one of the CEA objectives to which the IRFM strongly contributes, through fundamental studies on magnetized plasma physics or R&D on key components of MFE devices. Magnetic confinement fusion – which rests on the controlled fusion of 2 hydrogen isotopes (here, deuterium and tritium) heated to roughly 100 millions of °C (then in the so-called plasma state) and confined thanks to strong magnetic fields (in tokamak machines) - is actually seen as a viable approach to produce nuclear energy.

The IRFM has been assigned responsibility to conduct all theoretical, numerical and experimental MFE studies defined as priority by CEA for its "nuclear fusion" segment, which includes: (i) participation to the construction of ITER, to the European-Japanese "Broader Approach" and to the conceptual design of a demonstration fusion reactor (DEMO), and coordination of the corresponding national scientific and technological activities, in close contact with the involved international, european, national and regional structures; (ii) operation of dedicated platforms [WEST (W Environment Steady-state Tokamak, an upgrade of the TORE SUPRA tokamak - whose objective is to test the ITER tungsten divertor –

listed as national Research Infrastructure since 2015), cryogenics and superconducting magnets, plasma facing components, visible and infrared imaging, wave heating, robotics, virtual engineering, simulation]; and (iii) training of a new generation of physicists and engineers in fusion sciences.

These missions have been translated in 4 scientific and technical axes - (ST1) participating in the realization of ITER and the Broader Approach projects, (ST2) preparing the operation of next generation devices, (ST3) fusion physics understanding by theory and experiments, (ST4) fusion reactor studies - and 6 scientific themes on line with the managerial structure at the laboratories' level: (i) theory and simulation of the plasma core; (ii) divertor & plasma-wall interaction; (iii) integrated modelling, heating, scenarios & control; (iv) measurements & diagnostics; (v) plasma facing components; and (vi) cryomagnetism.

Unit workforce

Unit workforce	Number on 30/06/2016	Number on 01/01/2018
N1: Permanent professors and similar positions	-	-
N2: Permanent researchers from Institutions and similar positions	172	*
N3: Other permanent staff (technicians and administrative personnel)	85	
N4: Other researchers (Postdoctoral students, visitors, etc.)	31	
N5: Emeritus	-	
N6: Other contractual staff (technicians and administrative personnel)	16	
N7: PhD students	28	
TOTAL	**332**	
Qualified research supervisors (HDR) or similar positions	34	

Unit record	From 01/01/2011 to 30/06/2016
PhD theses defended	44
Postdoctoral scientists having spent at least 12 months in the unit	4
Number of Research Supervisor Qualifications (HDR) obtained during the period	9

* The total number of employees is supposed to stay flat (through full compensation of retirements); 10 recruitments have already been done since 01/07/2016 and the IRFM is under discussion with CEA for the following years.

2 • Assessment of the unit

Global assessment of the unit

The IRFM has correctly identified the key challenges in Magnetic Fusion Energy research and launched appropriate activities to address them. These activities allow reinforcing the international presence of the Institute, which is now playing a key role in EUROfusion and has become an essential partner of the ITER and Broader Approach projects.

No major concern was identified, even if some comments and recommendations were expressed.

More specifically, the committee of experts highlights the successful production of the first WEST plasma in December 2016. The dream project, at the time of the previous AERES evaluation, becomes reality thanks to the engagement of every facet of the IRFM personnel.

The committee of experts was impressed by the unique combination of theory, simulations, experimental validation and technology the IRFM has set-up to meet its obligations towards the ITER project and by the unique, vast and active network of national and international collaborators the IRFM has nursed and which shall be carefully cultivated in the coming years; in particular, bilateral agreements with Asian laboratories, signed to compensate a lack of internal resources to complete WEST, should not prevent the Institute from maintaining strong European relations.

Among the various achievements during the reporting period, it is worth noticing the development of state-of-the-art magneto-hydrodynamics (MHD), gyrokinetic and integrated modelling tools (leading to remarked simulations of core plasma turbulence or plasma edge physics) as well as the design and the manufacturing of the JT-60SA toroidal field coils, the creation of the Thermadiag spin-off or the development of impressive diagnostics, softwares and processes (*e.g.* for tungsten coating or material grading).

The implication of the IRFM in fusion reactor conceptual studies, the effectiveness of its new organization and the quality of its training program were also acknowledged.

The strategic objectives of the Unit, implemented through the four scientific and technical axes defined in the past and already approved by the previous evaluation panel, are clear and meaningful. The IRFM 10-year strategy is ambitious but the SWOT analysis is realistic and it is likely that the challenging objectives will be achieved.

The committee of experts is however concerned about potential sub-criticality in some scientific or technological areas. It encourages the IRFM to define priorities in order to fulfil its objectives, especially short-term WEST operation as a fully actively cooled divertor device and for long-pulse physics studies, and to secure as soon as possible the needed resources.