Evaluation 2005 – 2010

FOM Institute for Plasma Physics Rijnhuizen

The Hague, 2011

Netherlands Organisation for Scientific Research

Contents

1 Introduction

1.1 Scope and context of this evaluation

The Netherlands Organisation for Scientific Research (NWO) and the Foundation for Fundamental Research on Matter (FOM) regularly evaluate the scientific performance of its research institutes. As part of this evaluation scheme, the FOM-institute for Plasma Physics Rijnhuizen has been evaluated by an international committee. The aims of the assessment system were:

- Improvement of research quality based on an external peer review, including scientific and societal relevance of research, research policy and research management.
- Accountability to the board of the research organization, and towards funding agencies, government and society at large.

The committee was asked to produce a reasoned judgement on the mission, strategy and performance of the institute. The evaluation contains retrospective and prospective elements. The assessment is based on the Standard Evaluation Protocol 2009-2015 (SEP) (FOM-11.0317), which calls for an evaluation both of the research institute itself and of the research programmes it conducts. The research institute submits details of the results that have been achieved in each research programme over the previous six years (including quantitative data about staff input, key publications and a list of publications), a short outline of the mission statement of each programme, and details of developments anticipated in the context of the research profile of the institute. Important elements of each review are a site visit, which includes interviews with the management and the programme directors, and a tour of the facilities.

1.2 The evaluation committee

The evaluation committee was appointed by the Governing Board of NWO following consultation with FOM. Its members are:

- Professor Ron Parker (chair), MIT, Cambridge, USA;
- Dr. Thijs Viegers, Philips, Eindhoven, The Netherlands;
- Professor Sibylle Günter, MPI, Garching, Germany;
- Professor George Crabtree, Argonne National Lab, Argonne, USA;
- Dr. André Grosman, CEA, Cadarache, France;
- Dr. George Neil, Jefferson National Lab, Newport News, USA.

A short curriculum vitae of each of the members is included in Appendix 6.1. The committee was supported by FOM programme officer Dr. Jasper Reijnders.

All members of the committee have declared that their assessment is without bias, personal preference or personal interest, and that it has been reached without undue influence from the institute, the programme directors or other stakeholders. Any existing professional relationships between committee members and programmes under review have been brought to the attention of the committee. The committee has concluded that no conflicts of interest existed.

1.3 Data supplied to the committee

The documentation included all the information required by the SEP, as well as answers to the additional questions addressed to FOM-Rijnhuizen by NWO and FOM. It included:

- The self-evaluation report 2005-2010 by FOM-Rijnhuizen;
- The strategic plan FOM-DIFFER 2011-2016;
- A bibliometric study of FOM-Rijnhuizen by the Center for Science and Technology Studies.

During the site visit, handouts of all the presentations were made available.

1.4 Procedures followed by the committee

The committee proceeded in accordance with the Standard Evaluation Protocol 2009-2015. The assessment was based on the documentation provided by the institute and the interviews conducted during the site visit on 28-30 September 2011. The programme of the site visit is included in Appendices 6.2.

The documentation was sent to the committee one month before the site visit. The chair and secretary of the committee established a timetable for the site visit (see Appendix 6.2).

The committee was installed on the first day (Wednesday 28 September 2011) by Prof. Ben de Kruijff, member of the General Board of NWO in the presence of the director of FOM, Dr. Wim van Saarloos. Dr. Van Saarloos gave a presentation about energy research in the Dutch context and the recent national developments. Prof. Richard van de Sanden, director of FOM-Rijnhuizen, gave a short introduction of his institute. Afterwards the committee met in a closed session to finalize the division of tasks and the agenda for the site visit on day 2 and 3.

On day 2 (Thursday 29 September 2011), the committee discussed progress with all programme leaders and members of the research teams. The committee also visited the technical facilities and laboratories of FOM-Rijnhuizen.

On day 3 (Friday 30 September 2011) the committee met the Rijnhuizen director, Institute manager and division leaders and discussed the long term future research plans, the set up of the new institute DIFFER, the relocation process, knowledge transfer, education, outreach and finances, including the request for an increased mission budget. Also, the committee met the chairman of the Scientific Advisory Committee to talk about his views. The committee lunched with about 10 of the junior scientists in order to talk about their experiences at FOM-Rijnhuizen.

After that, the committee spent day 3 jointly discussing and writing a preliminary draft of the evaluation report and formulating the conclusions and recommendations. The conclusions of the committee were finally presented to the director of FOM and the Rijnhuizen management by Prof. Ron Parker. After the visit, the chairman together with the secretary prepared a proposal for the final version of the evaluation report. This report was sent to the director of FOM-Rijnhuizen to be checked for factual errors and approved by the committee members on 3 November 2011. The report was completed on 13 December 2011 and sent to the Governing Board of NWO on 14 December 2011. The Governing Board accepted the report on 25 January 2012.

1.5 Assessment scale

The committee used the scale provided in the Standard Evaluation Protocol (see Appendix 6.4).

2 FOM-Institute for Plasma Physics Rijnhuizen

2.1 Overview of the current institute: 2005 – 2010

2.1.1 Mission 2005 - 2010

The current mission of FOM-Rijnhuizen is

- To perform high-quality scientific research and to develop methods and techniques with that aim, in the field of Fusion physics, Plasma Surface Interactions, Generation and Utilisation of THz Radiation and Nanolayer Surface and Interface Physics.
- To train graduate and undergraduate students and technicians.
- To transfer high-level scientific and technical knowledge to the international research community, industry and society at large.

2.1.2 Scientific research

During the period of the review, the research programmes of FOM-Rijnhuizen focused on four lines of research:

- **Fusion physics**, comprising both fundamental research aimed at controlled fusion in the framework of ITER and the European fusion research programme for which Rijnhuizen acts as the national home-base;
- **Plasma Surface Interactions (PSI)**, comprising both in-house fundamental research and operation of the Pilot-PSI and Magnum-PSI devices;
- **Generation and Utilization of THz Radiation (GUTHz)**, comprising both in-house research and the exploitation of an international research facility, the free-electron laser for infrared experiments FELIX, for high-quality scientific research of external users;
- **Nanolayer Surface and Interface Physics (nSI)**, including applications in plasma physics, and short-wavelength optics.

Each line of research comprises of several research groups which is summarized in the table below:

Scientific division	Research group
Fusion Physics	– Plasma diagnostics – Tokamak physics – Computational plasma physics HT – ITER-NL
Plasma Surface Interactions	– Plasma surface interactions - Operations – Plasma surface interactions - Experimental – Low temperature plasma physics & heating – Computational plasma physics LT
Generation and Utilization of THz Radiation	– FELIX / FELICE – Molecular dynamics
Nanolayer Surface and Interface Physics	– Surface ion and photochemistry – Physics of thin films and materials – Advanced applications for XUV optics

2.1.3 Organisational structure

The research at FOM-Rijnhuizen is organized in scientific divisions, following the above-mentioned four research lines. Each division is headed by a senior scientist. Group leaders in each division report to the division head. Each project or programme has its own internal structure and project plan, agreed on by the Director.

The technical- and supporting functions of FOM-Rijnhuizen are embedded in a fifth division 'support facilities', headed by the Institute Manager. Staff functions HRM, Public Information and Safety & Health are led by the Institute Director.

Scientific division heads and Institute Manager report directly to the Director and are member of the Rijnhuizen Management Team. All major decisions concerning the operation of the institute are made by the management team.

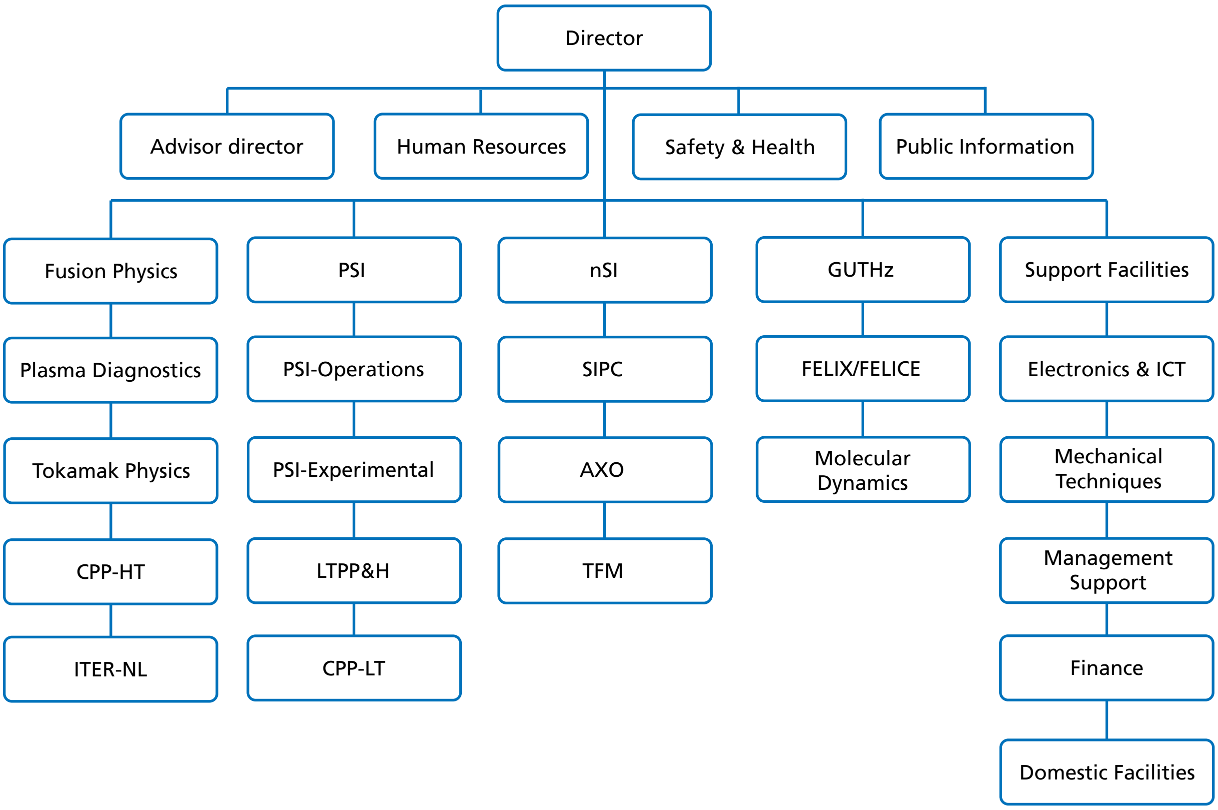

Figure 1 | Current organisational structure of Rijnhuizen

2.1.4 Financial matters

The running budget of FOM-Rijnhuizen is funded by four separate sources (see Figure 2) – FOM and NWO funding of the base budget of the institute (mission budget intended to cover the fixed costs), EURATOM and EFDA funding (EU contribution for the fusion related research in the framework of ITER and the European fusion programme), additional project funding acquired competitively by the institute from FOM, the EU, NWO, the Ministry of Economic Affairs etc., and funding from several industrial partners. In 2010, the total funding of the running budget of FOM-Rijnhuizen was about M€ 12, 57% (M€ 6,9) from FOM and NWO, 18%(M€ 2,1) from EURATOM and EFDA and 25%(M€ 2,9) from third-party funding. During the six years under review, the funding has increased with about 16%, mainly due to a (temporary) raise of the base funding by NWO and an increased (compared to the 2005 level) EU budget for fusion related activities at FOM-Rijnhuizen. The EU-funding of FOM-Rijnhuizen is however declining rapidly after a peak (M€ 4,2) in 2008.

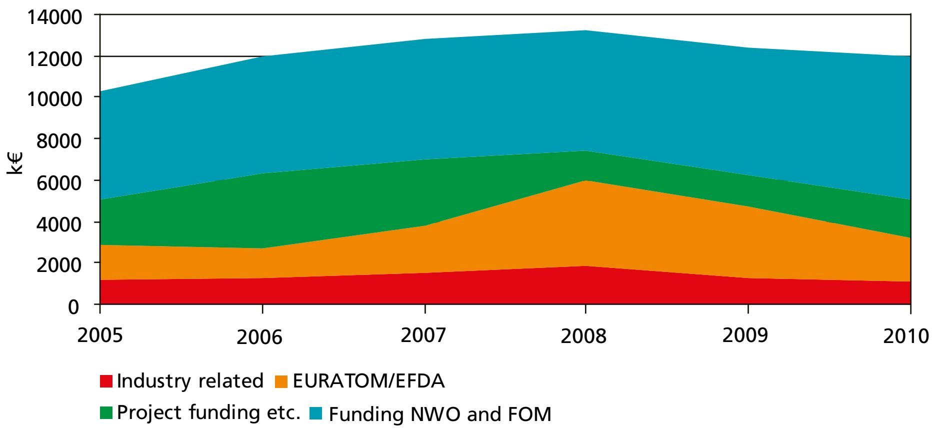

Figure 2 | Sources of funding 2005 – 2010 for Rijnhuizen.

2.1.5 Current staff

In 2010 the total number of permanent and temporary personnel at FOM-Rijnhuizen was about 153 Full time equivalents (FTE). This number comprises a scientific staff (including PhD's and postdocs) of about 67 FTE, about 63 FTE technicians and a supporting staff of about 23 FTE.

The number of personnel at FOM-Rijnhuizen has gradually increased by 14% during the period of review from ~133 to ~153 (see Figure 3). This reflects an increase of PhD-students and technical/supporting staff members. At the same time, the number of permanent personnel has increased from about 84 FTE (in 2005) to about 100 FTE (in 2010) mainly due to an increased number of permanent technicians.

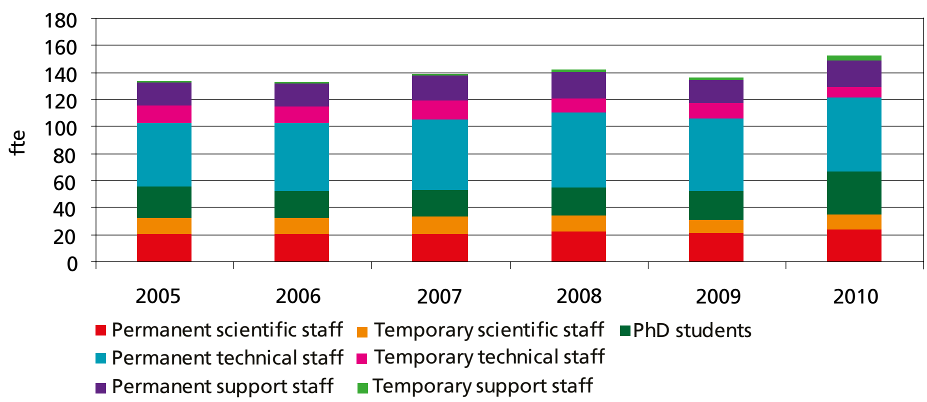

Figure 3 | Evolution of the staff profile 2005 - 2010 Rijnhuizen

2.2 Dutch Institute for Fundamental Energy Research (DIFFER)

In 2009 FOM and its parent organization NWO recognised the importance of focusing towards energy research. This was put forward in the FOM strategic plan 2010-2015, which gave FOM-Rijnhuizen a prominent position. It was decided by the Executive Board of FOM to expand the mission of FOM-Rijnhuizen into fundamental energy research and to evolve FOM-Rijnhuizen into a Dutch Institute for Fundamental Energy Research (DIFFER) with a national coordinating role in this field.

Late 2010, Professor Richard van de Sanden was appointed as the Director of DIFFER. The Executive Board of FOM gave him the important task to work out the new mission and lead the institute through the transition.

2.2.1 Relocation of the institute

In order to enable DIFFER to fulfil its new mission with emphasis on the national coordinating role and to realise a stronger connection to Dutch universities and university education, the Executive Board of FOM decided to:

- relocate the division of GUTHz (with its facility FELIX) to the Radboud University in Nijmegen where the FEL laser FELIX/FELICE will be brought under one roof with the complementing FEL-laser FLARE and the High Field Magnetic Laboratory. The new facility will become part of the RU Institute for Molecules and Materials (IMM) and, as such, be fully embedded in the science faculty. This will be effective in Q2 of 2013 and onwards. GUTHz will not be part of the institute DIFFER. The relocation of GUTHz will vacate budgets to be used for new energy research.
- embed DIFFER on the campus of the Eindhoven University of Technology (TU/e). This will be effective from 2015 and onwards. As part of the deal, TU/e will contribute a new research group in DIFFER.

2.2.2 Mission 2011 – 2015

DIFFER's mission is "to perform leading fundamental research in the field of Fusion energy and Solar Fuels, in close partnership with academia and industry, and to have a national coordinating role in the field of fundamental energy research."
In short, DIFFER performs "Science for Future Energy".
DIFFER pursues four equally important goals to achieve its mission:

- Performing top-level fundamental energy research in fusion and solar fuels;
- Designing, developing and operating high-quality technical infrastructure;
- Acquiring a national coordinating role in fundamental energy research;
- Further intensifying the collaborations with universities and Large Technological Institutes (LTI's).

2.2.3 Future research

DIFFER will focus on two research themes: Fusion Physics and Solar Fuels.
Within the Solar Fuels theme, two new research lines will be developed:

- **Materials and materials engineering for Solar Fuels** (MaSF) will focus on materials development and materials processing for solar fuel generation, addressing the issues of materials scarcity from the onset of the definition of the research.
- **Devices and processing technologies for Solar Fuels** (DeSF) will aim for novel devices and processing routes for the conversion of renewable energy to chemical fuels. The focus will be on plasma processing of materials under highly nonequilibrium conditions.

The research in the Fusion Physics theme will further build on the expertise of the existing scientific divisions Fusion Physics and PSI:

- **Fusion Physics** research will be focused on addressing the physics of burning plasmas, and, in particular, the control of MHD modes in these plasmas.
- **Plasma Surface Interactions** will aim for the Fundamental Understanding of the Physics and Chemistry of the Plasma Surface Interaction and Material Science for Solving the Plasma Facing Material Problem in Future Fusion Reactors. In a broader perspective the PSI division aims to investigate plasma surface interaction and plasma facing materials exposed to extreme loads other than nuclear fusion, such as (catalyst) materials for solar fuels. Finally the investigation of fundamental plasma physics and chemistry of high density low temperature plasmas forms an important objective.

2.2.4 Transition

In 2011 the institute consists of four research divisions, two of which are dedicated to energy research: Fusion Physics and Plasma Surface Interactions. To allow the institute to initiate new activities related to Solar Fuels, the two other divisions will pursue their own course.

The division Generation and Utilization of THz radiation will be relocated to the Radboud University Nijmegen starting from the second quarter of 2013.

Expectations are that a part of the division Nanolayer Surfaces and Interface Physics has equally good opportunities outside DIFFER. The institute management is undertaking actions to facilitate such a relocation. Remaining parts of the nSI division will stay within DIFFER as competences, expertises and infrastructure can be utilized and explored in synthesizing materials for solar fuel research.

Two new divisions will be established, following the proposed research efforts in Solar Fuels, i.e.: Materials and materials engineering for Solar Fuels (MaSF) and Devices and processing technologies for Solar Fuels (DeSF). The aim is to start with three research groups in each division. The new research groups can start as soon as the FELIX facility is relocated and a new experimental infrastructure can be built at DIFFER's current location in Nieuwegein. In other cases, and where appropriate, research groups will be stationed in university groups until the relocation to the TU/e campus has been realized.

The zijn organisational changes are reflected in the figure below.

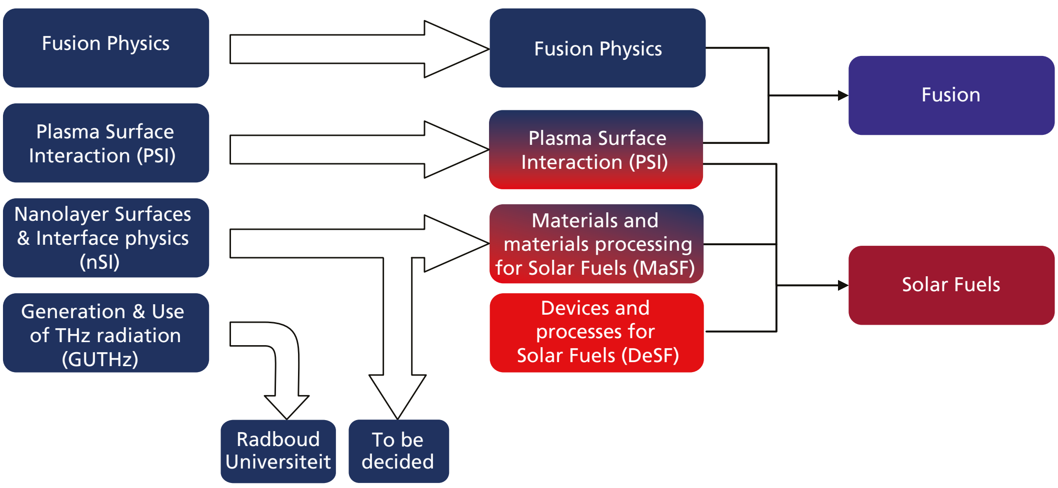

Figure 4 | Transition schedule from Rijnhuizen to DIFFER.

3 Assessment of the Institute

3.1 Answers to the Standard Evaluation Protocol

The committee grades the institute as indicated in the table below (scale 5 – 1; see also appendix 6.4). The section numbers refer to the sections where these grades are substantiated.

Assesment on	Grade	Section
A. Quality		
Quality and scientific relevance of the research	5	3.1.A1
Leadership	5	3.1.A2
Academic reputation	4,5	3.1.A3
Organisation	5	3.1.A4
Resources	5	3.1.A5
PhD training	4	3.1.A6
B. Productivity		
Productivity strategy	4,5	3.1.B1
Productivity	4,5	3.1.B2
C. Relevance		
Societal relevance	5+	3.1.C1
D. Vitality and feasibility		
Strategy	5	3.1.D1
SWOT-analysis	not graded	3.1.D2
Robustness and stability	5	3.1.D3

Overall assessment of the institute — 5

By all measures, namely scientific and technical success of its programmes, productivity and reputation of its scientific programme and staff, training of PhD students, technology transfer and valorization, the Rijnhuizen Institute has enjoyed an enviable period of achievement during the assessment period.

Looking ahead, the Institute is transforming itself to be better aligned with a 'Science for Future Energy' theme. It is proposing to do this by divesting the GUTHz and part of the nSI Divisions, and replacing them with two new Solar Fuels divisions: Materials and material engineering for Solar Fuels and Devices and processes for Solar Fuels or for Solar Fuels. This is a bold, high-risk, high payoff undertaking. High risk because of the high productivity the Institute is giving up in divesting the GUTHz and much of the nSI divisions, uncertainty in the most profitable technical directions to pursue, and the time it will take to build up the necessary expertise; high payoff in view of the magnitude and impact of the potential contribution it can make to the practical realization of solar fuels. An additional aspect is the move of the newly named DIFFER Institute to the campus of the University of Eindhoven, which will undoubtedly enhance the educational component of the Institute's mission.

Based on the Institute's impressive performance during the evaluation period, as detailed below, and its forward looking strategy to address one of society's most urgent needs, the Panel gives the Institute a score of 5 in its overall assessment.

3.1 A1 Quality and scientific relevance of the research — *5*

The overall quality and scientific relevance of the research is judged to be exceptional.

In the Fusion division, the development and application of the electron cyclotron 2D imaging system has led to new understanding of the decades old phenomena of sawtooth crashes in tokamak discharges. Originally developed within the frame of the TEXTOR collaboration, the ECEI diagnostic has now been upgraded and exported to ASDEX UG in Garching. A similar system has been designed and installed, and has begun operation, at the KSTAR tokamak in Korea. A second example of world-leading research has been the use of an ECE diagnostic to detect an MHD instability and control it via feedback using electron cyclotron heating delivered through the same sightline used to observe it. Control of this instability in ITER is essential and the work by the Rijnhuizen group is making an important contribution, both through the fundamental understanding obtained with the ECEI diagnostic and with the technical advances made in its control. The Panel is also impressed that the Fusion Division is taking on development of key diagnostics for ITER. Both the CXRS spectrometer and a launcher for EC waves will assure important and highly visible roles for Rijnhuizen during ITER operation

In the PSI division, the Panel regrets that fabrication problems prevented the first scheduled operation of Magnum PSI; however the Panel is pleased that the PSI team has explored the option to proceed with copper magnets. The Panel notes that the steady-state particle fluxes expected in Magnum PSI can not be produced in any other device in the world. It therefore continues to support its development, recognizing that its performance will be unique and invaluable in understanding plasma-wall interactions at ITER-level power and particle fluxes. Meanwhile, impressive performance unachievable in any other facility has been achieved on a pulsed basis on Pilot PSI. This has resulted in new understanding of the behavior of hydrocarbons formed by the interaction of plasma with graphite targets. As ITER has shifted its position away from using carbon in its nuclear phase, the pilot research programme has been appropriately redirected to the study of plasma-tungsten interactions. Extension of Pilot to simulate the particle and heat loads of ELMs is applauded.

The nSI division conducts a world leading programme in the field of thin film and interface physics. It is truly multidisciplinary, including photochemistry, plasma physics, and short wavelength optics, and it has a strong application focus on multilayer optics for advanced short wavelength radiation sources. The main application is in the heart of new generations of photolithography machines for the fabrication of integrated circuits. Intimate collaboration exists with optics manufacturer Carl Zeiss and the producer of lithography equipment ASML. Basic understanding of the physics of thin films and multilayers has led to improved control of surface and interface chemistry resulting in world record reflectivities. Another application is in optics for EUV radiation. The realisation of a unique beam splitter for short wavelength radiation based on a stress free multilayer structure, deposited on a thin film membrane, is an example, which has been received enthusiastically by the free electron laser user community. A third programme focuses on the processes of degradation during the usage of the optical elements. It deals with issues like diffusion on extremely small scales to be able to predict the lifetime of optical elements on a macroscopic scale. It also involves in-situ monitoring of contamination at unprecedented low levels. A new industrial partnership programme addresses these photon and plasma induced processes at EUV optical surfaces.

The GUTHz division offers the international community access to a bright tuneable radiation source in the 3 to 250 micron range, runs a molecular physics research effort aimed at structure and dynamics of complex molecules, ions and clusters in the gas phase, and offers opportunities for research in solid state physics and ion spectroscopy of bio molecules. The programme is perhaps the most productive long wavelength FEL photonics research effort in the world with a sizeable portfolio of interesting publications and significant contributions in a number of technical areas. The development of the FELICE beamline for intracavity enhancement of intensity along with the molecular beam apparatus and Fourier Transform Ion Cyclotron Resonance mass spectrometer has been a major capability addition paying off handsomely in terms of research output. In their niche of long wavelength operation this work is world leading and the overall operation of the facility is a model for how to mount a successful programme on modest resources.

The number of refereed journal publications per scientific staff member averages 2,2 per year over the assessment period. This is a reasonable rate of publication, not exceptional but close to the norm that might be expected from an institute with its mix of scientific and technical areas of expertise. Over 30% of the publications appear in high impact journals, defined as those with an ISI impact factor of 4 or more. An extensive analysis of Rijnhuizen's publication record has been provided to the Panel in the document 'Bibliometric Study on FOM Rijnhuizen, (2005-2009/2010)'. According to this study, the mean number of citations per article (excluding self-citations) relative to the field averaged value is a respectable 1.16, i.e., the institute's publications receive about 16% more citations than the international standard spanning the same fields of research. It is to be noted that the Plasma Diagnostics Group and the GUTHz Division have a field averaged impact of 1,53 and 1,54, respectively, which is considered to be remarkably high. It is to be noted that the multidisciplinary applied and technical character of the work in the nSI division makes the citation indexes and calculated impact values of its papers less appropriate, which weighs down the scores for the institution as a whole.

3.1 A2 Leadership — 5

During most of the evaluation period, the Institute has been led by Prof. Aart Kleyn. This has been a somewhat difficult and eventful time, beginning in 2003 when the FOM Board decided to reduce the emphasis on fusion research leading to a 50% budget cut in this area by 2004. With the initiation of the ITER Project and the opportunities afforded by the formation of ITER-NL, fusion has once again become a central pillar in the Rijnhuizen programme as it moves into an energy oriented programme. The mission of the Institute was also redefined during this evaluation period to be characterized by 'Physics for Energy', which has now evolved into the present 'Science for Future Energy' mission of DIFFER. A consequence of the new orientation is the splitting off of two highly productive components of the Institute, the GUTHz and parts of the nSI Divisions. Maintaining the high productivity that the Institute has enjoyed over the past 5 years will indeed be a challenge for Dr. Van de Sanden, as DIFFER undertakes its future energy mission.

Additional unexpected issues during the evaluation period occurred with the fire in FELIX in 2006 and the failure in the manufacture of the PSI magnets. Unexpected events such as these have precedence in the fusion (e.g., W7-X magnets) and particle physics communities (LHD start-up), but nevertheless might have been better anticipated.

Overall, the Director together with the Division Heads have steered the Institute well through this transitional and occasionally unsettled period, and deserve high marks for effective leadership. The Panel wishes Dr. van de Sanden continued success as he leads DIFFER with its new and exciting expanded energy mission.

3.1 A3 Academic reputation — 4,5

Prof. Aart Kleyn has been the Director of Rijnhuizen Institute from 2003-2010, covering the period of the evaluation. He was trained in physics and has a broad range of interests, publishing over 300 papers in a variety of fields, predominantly on surface science and more recently on plasma-surface interactions. Prof. Kleyn has supervised nearly 40 theses. He has served on many panels both in the Netherlands and abroad, has presented over 100 invited talks and lectures at international conferences and is clearly internationally renowned. He has served as President of the Netherlands Physical Society, is a Fellow of the Institute of Physics (UK) and has been active in the area of science policy and management in the Netherlands. His broad range of contributions, interests and experience easily qualifies him for his position of Director of the Institute.

Prof. Tony Donne is very well recognized in the fusion community, and is renowned for many exceptional and novel diagnostic developments. It is certainly due to his leadership that the diagnostics group at FOM can be considered the most productive and innovative one in Europe, if not world-wide. His knowledge however goes well beyond diagnostics: he can provide leadership in all areas of the fusion physics group.

The leader of the GUTHz effort, **Dr. L. van der Meer**, has established a strong international reputation for effectiveness in scientific leadership. Though modest in scope his laboratory has an exceptional reputation and productivity. Over more than a decade Dr. van der Meer has mentored many other scientists in the field. He has been a long-time member of the FEL International Executive Committee and has been sought after for advice and support in the development of many new facilities in both Europe and the US. The fast commissioning of FLARE is undoubtedly in part due to his and his team's exceptional capability and experience. His development of the FELICE intracavity system significantly enhanced the productivity and scientific capability of FELIX. His courageous and foresighted establishment of a new home at FLARE for FELIX and FELICE is to be commended as a benefit to the personnel involved. In addition, the future research output of both institutions will benefit from the synergy of the complementary capabilities.

Prof. Fred Bijkerk conducted 40 European and national science & technology projects in the field of thin film and multilayer physics and technology, with a total funding of M€ 36 from national science foundations, industry, European community programmes, and national government. In this field he filed 33 patents and published 80 journal articles, among others. Many of his scientific results have been or are being transferred to industry. He won the FOM valorization price for the activities of his division. Among his major research achievements are the first European demonstration of EUV lithographic imaging using 13 nm radiation, and the development of multilayer coating technology to world record reflectivity values.

Prof. Jürgen Rapp has been well known for having developed studies of the plasma edge in the tokamak TEXTOR, and especially for relating an improved plasma confinement mode to the control of edge radiation, also in TEXTOR. His capability to bring European physicists together was substantiated in JET where he headed the operations department at the JET Close Support Unit and among other activities promoted development of good confinement modes involving a sufficiently high level of radiated power in JET, a promising mode for ITER. Such studies involve a good knowledge of plasma wall interactions, so that he could be selected as leader of the newly formed plasma surface interactions division at FOM-Rijnhuizen, which proved to become more productive during the four years he spent with it.

3.1 A4 Organisation — 5

The Institute is organized into five divisions, each containing 2-5 relatively small groups. This organisational structure is entirely appropriate for a research laboratory of this size. Biweekly meetings of the top management, where major decisions that concern operation of the institute are taken, occur at an appropriate frequency and assure good communication from the director to the division heads. Human resources, safety and public relations all report to the director, which is necessary for organizations of this type and size. Group leaders and heads of major projects meet every six weeks to discuss scientific issues and long range planning. The scientific programme is reviewed annually by the Scientific Advisory Committee, while priorities and allocation of run time for FELIX are determined by a committee of external users.

The management has dynamically transformed the divisional structure in light of changing priorities and mission. At the beginning of the assessment period (2005) the scientific programme was structured in 2 divisions, Plasma Physics and Molecular and Laser Physics. With the synergistic joining of PSI and LPX groups, the nSI division was created in 2006. Also the Plasma Physics division was renamed Fusion Physics, which reflected the increased orientation toward fusion energy stimulated by the launch of the ITER project. The overarching mission was 'Physics for Energy' although, as pointed out in the 2002-2008 Assessment, it was not clear how GUTHz and parts of the nSI Divisions would fit under this umbrella. Toward the end of the assessment period in early 2010 the plasma-surface activity was split off from the Fusion Division to form the present alignment of 4 divisions: Fusion Physics, Plasma Surface Interactions, Generation and Utilization of TeraHertz and nanolayer Surface and Interface Physics. Each division is composed of two or more groups which makes a clean management structure with clear lines of responsibility.

Further reorganization is envisaged in the near future as the GUTHz division moves to Radboud University in Nijmegen and the nSI nanolayer group finds a new home. Thus the Fusion and PSI Divisions, together with the new Solar Fuels Division, will provide a logical framework for the energy-oriented mission.

From this evolution in the divisional structure during the past 5 years one sees a dynamic organisation with the flexibility to adapt to changing priorities and mission. The Panel applauds the efforts of the Director (Kleyn) in adjusting the management structure to maintain the proper alignment to the scientific program.

Importantly, the Panel also commends the Director (Kleyn) for initiating new, vibrant research programmes during this period, including

- Construction and operation of FELICE, a world class FEL facility for carrying out fundamental studies on free molecular systems;
- Acquisition of an Advanced Deposition Coater which has enabled the institute to continue its world-leading role in the field of reflective optics in the EUVL, as well as to strengthen its partnering role with Carl Zeiss and ASML;
- Investment in the MAGNUM PSI facility, a linear device which is capable of generating plasma fluxes at the level expected in ITER;
- Initiation of several new programmes, including ITER-NL, Advance Control of MHD Modes in Burning Plasmas (CBP), Controlling Photon and Plasma-induced Processes at EUV Optical Surfaces (CP3E) and EXEPT.

Overall, the Panel gives the management the highest grade for establishing a crisp and dynamic management with clear lines of responsibility which is well-matched to the tasks defined by the evolving scientific programme as it supports the changing mission.

3.1 A5 Resources — 5

On the basis of the high scientific productivity and impact in the areas in which Rijnhuizen scientists have chosen to make contributions, the Panel finds the overall quality of the scientific staff to be outstanding.

Moving forward, it will be a considerable challenge to maintain the high level of staff as the Institute competes with other laboratories, institutes and universities for the top quality personnel necessary to kick start the new programmes within the proposed new MaSF and DeSF divisions. Fortunately, it is assumed that the bulk of the personnel in the Fusion and PSI divisions will stay with the Institute as it moves to Eindhoven. The Panel applauds the efforts that the Institute is making to make the transition as attractive as possible.

The institute has been resourceful in seeking funding over the past 5 years. Its ability to attract over M€ 1 per year from industrial funding, while maintaining its strong scientific orientation, is impressive. Base funding from FOM and NWO has seen a growth of approximately 30%. The financial earning power, defined as the ratio of competitively won resources to the base FOM/NWO support averaged an impressive 160 % over the assessment period. Funding from EURATOM and EFDA rose sharply in the middle of this period, mainly due to funding for ITER-NL (which in large part passed through to industry) but has been declining since. A further decline in EURATOM funding is anticipated as part of a European-wide trend to identify resources for ITER construction.

The Institute is asking for a compensatory increase of 200 k€ in the mission budget to counter this decrease. The Panel strongly supports this request.

The Institute's principal facilities during the assessment period have been the FELIX/FELICE FEL and PILOT PSI. The former facility has been successfully operated as both a user facility, attracting many collaborators from outside the institute, as well as a facility for carrying out in-house research. The FELIX/FELICE will continue operation at Radboud University Nijmegen, merging with the FLARE FEL to form a world class facility for the generation and use of THz radiation.

The PSI work that was carried out on the PILOT device will continue on the upgraded facility MAGNUM. The setback suffered by MAGNUM due to failures in the manufacture of the super-conducting magnets will be offset in the near term by operating with copper magnets. Although this will mean a decrease in the magnetic field, MAGNUM will still be the only laboratory plasma device in the world capable of producing ITER level particle fluxes (10^{24} $m^{-2}s^{-1}$) at relevant power densities (~ 10 MW/m^2), albeit at relatively short pulse lengths (~7 s). The research carried out on this device in exploring the effect of such high particle and power fluxes on various materials will be crucially important to ITER. The Panel looks forward to the operation of MAGNUM with its superconducting magnets, new environment and augmented research team at Eindhoven.

3.1 A6 PhD training — 4

Part of Rijnhuizen's mission is to train graduate students. Since the Institute does not grant degrees, PhD students are supervised by staff members who are part-time or adjunct professors at various universities. In addition, full time university professors have the opportunity to place students at the institute to carry out their graduate thesis research, benefitting from the day-to-day supervision by Rijnhuizen staff members. This arrangement is a win-win situation, both for the students who get access to world class facilities and first rate mentoring, and for the institute which benefits from an expansion of its workforce and enhanced productivity. A total of 15 faculty and staff are involved directly with student training, divided about equally between institute staff and full time university faculty.

On average over the assessment period, 4 PhD's have graduated per year. Assuming a residence time of 4 years yields an average of about 1 graduate PhD per faculty member. In the self-assessment document the number of PhD students at the end of 2010 was 34 – which would correspond to over 2 students per faculty member. This apparently reflects a concerted effort to expand the PhD-training component of the institute's mission, a strategic action which is strongly endorsed by the Panel. The present level is planned to increase to about 3 PhD's per professor, which would seem to be about the right target.

3.1 B1 Productivity strategy — 4,5

The productivity strategy of the Institute in recent years has mainly been to increase the number of PhD students. This strategy has been successful as the ratio of PhD students to faculty members has doubled, from about 1:1 to 2:1. This has produced a corresponding growth in overall publication rate as well. As the Institute is well aware, and consistent with its plans, it is desirable to continue this trend, aiming at a ratio of about 3:1 PhD students to permanent scientific staff.

3.1 B2 Productivity — 4,5

Rijnhuizen is primarily a scientific institute and as such the best indicator of its productivity is its publication record, appropriately weighted by impact. The number of refereed journal publications per scientific staff member averages 2,2 per year over the assessment period. This is a reasonable rate of publication, not exceptional but close to the norm that might be expected from an institute with its mix of scientific and technical areas of expertise. Over 30% of the publications appear in high impact journals, defined as those with an ISI impact factor of 4 or more. An extensive analysis of Rijnhuizen's publication record has been provided to the Panel in the document 'Bibliometric Study on FOM Rijnhuizen, (2005-2009/2010)'. According to this study, the mean number of citations per article (excluding self-citations) relative to the field averaged value is a respectable 1,16, i.e., the institute's publications receive about 16% more citations than the international standard spanning the same fields of research. It is to be noted that the Plasma Diagnostics Group and the GUTHz Division have a field averaged impact of 1,53 and 1,54, respectively, which is considered to be remarkably high.

The FELIX/FELICE facility has been extremely successful in attracting visitors and collaborators, as about 80% of the users of the facility came from outside the Institute. The Institute is to be congratulated in establishing FELIX/FELICE as a user facility while maintaining a strong in-house research team. The Panel recommends following the same model as the facility is established in the Radboud University.

Outside participation in the MAGNUM facility has been slow to develop due to the delay in its completion. Nevertheless the unique capability of this facility when it comes into operation should make it very attractive as a draw for outside collaborators. The experience gained in operating FELIX as a facility for both in- and out-house users should be valuable input for establishing a similar role for MAGNUM.

The Fusion Physics Division has been very active in public outreach. The Fusion Road Show – an FOM invention – has been a great success, and sets an example on how the public can be informed about the scientific work in this field and its potential role in a future energy mix.

3.1 C1 Societal relevance — 5+

The Institute is keenly aware of the need to provide a return on investment to the stakeholders, and has scored a number of successes in this direction. The most outstanding example is the development of multilayer EUV optics in the nSI Division that has made possible a new generation of photolithography for the fabrication of integrated circuits. This work is carried out under the Industrial Partnership Programme CP3E and involves the Carl Zeiss Company and ASML in addition to members of the nSI Division. Another example is furnished by the Institute's participation in ITER-NL, which provides pathways for Dutch industry to win contracts for the fabrication of components for ITER.

Looking ahead, plans are in place to initiate a Center of Excellence (CoE) in Intellectual Property management in the DIFFER. Its goals will be to:
- enhance accessibility (of the Institute's research) to industry;
- advise on patent applications and develop and maintain a patent portfolio strategy;
- advise on knowledge transfer to industry and valorisation of scientific results;
- coordinate basic research on advanced energy production on a national level.

This type of industrial liaison activity is well known in the US where it has been highly successful in facilitating knowledge transfer from research to practical applications. The Institute might consider enlarging the mission to include facilitating the formation of start-up companies, which former students and staff might wish to form as a result of their research breakthroughs. Models for this type of activity exist in the US and probably also elsewhere in Europe. The Panel enthusiastically endorses this emphasis on valorisation and the Institute's plans for the CoE.

3.1 D1 Strategy — 5

As it moves into the next evaluation period the Rijnhuizen Institute is revising its mission to correspond to the theme ‘Science for Future energy’. It will be renamed DIFFER, the Dutch Institute for Fundamental Energy Research and relocated at Eindhoven University. Its strategic vision will entail the following goals:

- Perform top-level fundamental energy research into fusion and solar fuels;
- Design, develop and operate high-quality technical infrastructure;
- Acquire a national coordinating role in fundamental energy research;
- Further intensify collaborations with universities and Large Technological Institutes.

The Panel supports this new thrust, while at the same time acknowledging the relatively high risk in entering a strongly competitive new area with minimal in-house prior experience, and losing the very successful GUTHz and much of the nSI Divisions. Fortunately the Fusion Physics and PSI Divisions are stable and have well-defined paths forward, even with the prospect of diminished EURATOM funding.

The Panel observes that locating DIFFER at Eindhoven by itself does not assure integration into the university environment. DIFFER’s staff will be a mix of full time university professors and full time institute staff. The management needs to take care that these positions are perceived as having comparable status, and that the institute is not isolated from the university. Having access to top quality students at the university is a huge advantage, but there is also a responsibility to ensure that students are properly educated beyond the immediate need to carry out their research.

The Panel also is concerned that attempts to provide a ‘coordinating role’ could be misunderstood and might be viewed with suspicion and even hostility by some already heavily engaged in energy research.

As the DIFFER management is well aware, recruiting top talent to fill the group leader positions will be a major challenge. It will be important to demonstrate early successes in DIFFER’s solar fuels program, establishing that DIFFER will be a serious player in carrying out in-house energy research.

FOM and NWO must be patient as this new activity is launched and anticipate that a few missteps (we hope not too many!) undoubtedly will be taken.

3.1 D2 SWOT-analysis — **Not graded**

The SWOT analysis presented by the institute is reproduced below:

Strengths	Opportunities
– Excellent track record in large experimental facilities, e.g. Magnum-PSI – Unique scientific expertises in fusion and plasma physics/chemistry, surface and interface science, and materials processing on the nanoscale – Very good publication track record – Excellent track record in public-private partnerships and in obtaining external funding – National home base for fusion research in the context of Euratom	– Multi disciplinary Solar Fuels research attractive for excellent tenure trackers – Magnum-PSI as worldwide leading fusion related PSI experiment – Energy research aligns well with Dutch Top Sector policy and with NWO and FOM strategies – Coordination and streamlining of multidisciplinary fundamental energy research in the Netherlands – Use-inspired research leading to private-public partnershiips
Weaknesses	**Threats**
– No track record in Solar Fuel Research – Low ratio temporary/permanent research staff – Large dependence on external funding	– FES funds no longer available to fund ITER-NL research – Declining Euratom funding – Excellent tenure tracker difficult to hire due to fierce competition – National energy research difficult to coordinate

The Panel would suggest that the track record in large experimental facilities is less than excellent considering the problems with MAGNUM and the fire in FELIX. Nevertheless, the experience gained is invaluable and emphasizes the need for management oversight in areas such as major procurements and safety.

We are surprised that embedding DIFFER into Eindhoven University is not called out as a strength. In 'opportunities' it would make sense to identify the new research areas which the Institute is well equipped to address by virtue of its existing areas of expertise. Also, again, the opportunities presented by the embedding of DIFFER into the university setting might be mentioned.

We agree that the biggest threats are the difficulty to build up first-rate staff for the SF part of the research plan and potential obstacles in coordinating national energy research. The FOM and NWO must understand that the SF initiative is high risk/high gain. It can succeed but may take longer than the somewhat optimistic time scale foreseen in the Strategic Plan.

3.1 D3 Robustness and stability — 5

The Institute's overall funding has been reasonably stable over the past 5-6 years, although there has been some variation in the level of individual sources.
The panel considers the quality of the staff to be exceptionally high and at least competitive with other institutions.
The divesting of the two divisions has been embraced by most of the staff due to the very admirable efforts of the management to facilitate the transition.

3.2 Answers to the questions addressed to the committee by NWO

Six questions were put by NWO in addition to the Standard Evaluation Protocol.

3.2.1 Is the mission still correct and fitting? Considering the mission of the institute, is there a proper balance between the research, R&D and research facilities (their development and use)?

The mission of the Institute has been revised recently to embrace
- *Fundamental energy research in fusion physics and solar fuels.*
- *Designing, developing and operating high quality technical infrastructure*
- *Acquiring a national coordinating role in fundamental energy research*
- *Further intensifying the collaborations with universities and Large Technological Institutes.*

The mission in fusion continues a long-standing emphasis and remains fully appropriate. The addition of a broader energy portfolio including emphasis on solar fuels and acquiring a national coordinating role in energy research is correct and fitting to the institute's capabilities and the national need for a coherent approach to energy research. The institute has a history of creating and operating high quality technical infrastructure such as FELIX/FELICE, the Pilot PSI, and a leading nanoscale fabrication and characterisation laboratory; this history and capability is properly reflected in its new mission statement. Further intensifying collaborations with universities and Large Technological Institutes is very appropriate as it will produce more effective R&D and promote the demonstration and deployment of new technology. The Institute has an excellent record of fundamental research, R&D, and research facilities including, among others, plasma-surface interactions and molecular dynamics using THz radiation, forefront THz facilities FELIX/FELICE, and translation of frontier EUV mirrors and technology to industry. These activities are in appropriate balance.

3.2.2 What is the national and international importance of the institute, now and in the near future? Is the institute's policy ready for new challenges?

In the new direction of the Institute, fusion is still a big part. The position of this programme is excellent, world leading, and in the forefront of its field. It has an impressive impact, a tremendous outreach, and is very much in line with ITER. In the solar fuel programme there is the risk that the position of the institute still has to be established.

It must be noted that the institute spun out two very successful divisions, the GUTHz division to the RU Nijmegen and the nSI division to 'still to be decided', thereby delivering an important contribution to the international position of science in the Netherlands.

3.2.3 Should NWO continue to support the institute, if so, for what reasons? Are there more effective alternatives for NWO for supporting the same type of research and/or facility?

It is important that NWO continue its strong support for the institute because it has been a highly effective research institution. The institute's new directions address concerns of international societal import and have a high likelihood of achieving important output over the long term. The country benefits in the nearer term from the education provided for undergraduates and graduate students in high technology. Such technical education has proven elsewhere to be a driver for innovation and industrial growth. The institute has attracted significant outside support in the past and is well-positioned to leverage NWO funds to win additional support for the new thrusts in the future. We have not identified a more effective alternative for achieving such a return (educational, societal, and economic) on investment.

3.2.4 Does the institute sufficiently use any opportunities for co-operation with organisations outside the academic world?

The foundation of ITER NL was a major step on the way to involve Dutch industry into the ITER project. It enables the industry to receive ITER contracts, while at the same time it enables the FOM Rijnhuizen institute to significantly contribute to the diagnostic development of ITER. In this respect, as well as in its successful contributions to world-leading tokamak experiments, the institute can serve as a role model for other European laboratories. The nSi division provides a further example with its successful collaboration with Carl Zeiss and ASML.

Late 2009, the board of FOM decided, with NWO's agreement, to change the mission of the FOM Rijnhuizen institute and make it the national institute for fundamental research on energy. In the light of this new mission, it was also decided to move the institute to a university campus. The chosen location is the campus of Eindhoven University of Technology.

3.2.5 What are the implications of these changes for the work and organization of the institute, for its national support and research role, and for its national and international position within the field

The implications for the work and organization of the fusion department and its high standing in the field are unchanged by the DIFFER mission.

On the other hand, the extension of the mission to include solar fuels and to take on the role of a national coordinator of energy research introduces profound changes in all of the aspects mentioned in the question above. This will first of all require the creation of two new Solar Fuels divisions: Materials and material engineering (MaSF) and Devices and processes (DeSF). Since the Institute does not have a track record in the Solar Fuels arena, its biggest challenge will be to rapidly establish itself as a key player on the national and international scene. Three groups are foreseen by the Institute in each division, and each group will need to be staffed with a new tenure track position, a PhD student and a technician. Apart from the resources freed up by the move of the GUTHz, the additional budget needed to realise this staff build up equals ~M€ 0.8 of structural funds plus temporary funds for startup packages k€ 325 per year for 4 years. The panel supports this request as a reasonable level of support for the Solar Fuels divisions.

3.2.6 What choices need to be made regarding the in-house activities of the institute over the next six years? How will FOM Rijnhuizen prepare itself for these choices in the coming period?

The new mission for FOM Rijnhuizen requires substantial preparation in the area of non-fusion energy research. The Institute has selected Solar Fuels as its emphasis area, requiring a thorough catalog of Dutch, European and international activities in this field to appreciate the landscape of individual and institutional players, ideas and approaches. The decision of which scientists and areas of solar fuels research to emphasize should be made in tandem, allowing maximum flexibility to tailor the scientific team, the topic and the national fabric of related research. The national coordinating role likewise requires a thorough catalog of Dutch energy research and societal needs, in order to make strategic decisions of directions, scope and balance.

National coordination requires offering financial resources to research teams to encourage changes of their direction. Natural sources for these funds include energy businesses that seek innovations that significantly improve energy technology. Inviting these companies to suggest research areas and to contribute funding which is ultimately distributed by FOM following advice by the Council for Energy and DIFFER provides a coordinating mechanism for matching national and industrial needs with basic and applied research interests and capabilities.

3.3 Assessment of the future mission and strategy of DIFFER

Overall Assessment

Reorganisation of FOM Rijnhuizen to the Dutch Institute for Fundamental Energy Research (DIFFER) is a commendable strategic, scientific and societal transition. The need for fundamental energy research is clear: sustainable energy phenomena are inherently quantum in nature, couple photonic, atomic, electronic and molecular components in complex architectures, proceed by sequential dynamic steps and are often not understood at either the individual component or the aggregate level. The realization that long-term fundamental research in sustainable energy is a basic societal need for meeting energy needs for the next half-century and beyond is a new and powerful guiding principle that changes our basic attitudes toward science. FOM's strong and incisive action in incorporating this new guiding principle into its philosophical and operating environment is courageous, forward-looking and praiseworthy.

The refocussing addresses many issues and is capable of producing many positive outcomes. First and foremost is the generation of new knowledge on the static structures and dynamic phenomena of sustainable energy conversion, serving society well into the future. A second positive outcome is the implementation of a structure and process for defining strategic directions in fundamental energy research, and for launching them in the areas of solar fuels through DIFFER and in the areas of organic photovoltaics and light management (among others to come) through FOM-funded focus groups in universities. A third positive outcome is the encouragement of cooperation among the research efforts in DIFFER, universities and the Large Technological Institutes. Fourth is an enhanced training of students and their continued mentoring beyond the PhD to become the next generation of research leaders among faculty at universities and staff at industrial institutions. Finally, the management of intellectual property, the transfer of knowledge from science to industry and the encouragement of start-up companies to exploit new opportunities will tighten the discovery-innovation-deployment pipeline, an especially important track for advancing sustainable energy technologies. FOM is to be commended for folding so many positive outcomes into a single reorganization package.

Future Perspectives

The restructuring plan is a bold strategy that has yet to approach most of its challenges. The plan has many excellent features in moving to TU/e where there is a vibrant and diverse academic community with many opportunities for synergistic research and training of students and early career PhDs. Providing a new building for DIFFER and attractive start-up packages comprising tenure track positions, research students, staff, and research funding promotes the recruiting of top talent. Establishing a high level Council for Energy Research to provide guidance and balance to national strategic themes will maintain focus.

Along with these attractive features, the reorganisation will face challenges. Obtaining buy-in from the existing research groups in the coordination of a national strategy will require thoughtful and deliberate attention. The research directions in Solar Fuels remain largely undefined beyond a few generic outlines, and there is not a prior foundation within DIFFER from which to develop them. The focus on Solar Fuels is rich with fundamental research opportunities; at the same time it is still in its infancy, far from the application stage and so may not produce the desired societal benefit of energy storage in chemical bonds on a reasonable time scale. To have a nearer term societal impact, other energy research directions (for example, catalysis, batteries and fuel cells) will have to be represented in the national coordination plan.

Recommendations

- The initial perception and long-term success of the Solar Fuels programme will depend critically on its early achievements. Recruiting the early hires and designing the initial course of the research to have high impact are key features to be deliberately and thoughtfully implemented.
- The strategic focus on Solar Fuels is fundamental, opportunity-rich, and attractive to top rank researchers. Its long time to societal payoff, however, should be balanced by emphasis of additional efforts, perhaps in the national coordination plan, on nearer term societal payoff directions. Strong candidates include catalysis and electrochemistry, which are as fundamental as solar fuels and have more plentiful near term applications.
- The FOM Rijnhuizen is primarily a physics-centric organisation, while Solar Fuels and other alternative energies are much more interdisciplinary. Attracting top rank chemists, materials scientists and nanoscientists should be an early priority, to communicate the intentions and seriousness of DIFFER in carrying out its energy mission and to attract the second round of top multidisciplinary talent in these fields.
- The discovery-innovation-deployment pipeline is receiving new attention in many countries, with the goal of bridging the ‘valleys of death’ that often separate discovery from development and development from deployment. The to be installed CoE should examine the gaps in the discovery-innovation-deployment pipeline in the Netherlands and take steps to streamline its effectiveness.

4 Past performance: research programme assessments

4.1 Research programme of the Fusion Physics division

Current research programme leader:	Tony Donné
Tenured staff:	6,3
Other personnel (end 2010):	5,8 Postdocs, 10,9 PhD-students, 5,7 Technical Staff
Publications (2006-2010):	229

Quality	5
Productivity	5
Relevance	5
Impact	5
Vitality	5
Overall	**5**

Overall assessment

Although there is no embedded experiment to tackle fusion physics anymore at Rijnhuizen, the fusion physics division succeeds in contributing to the solution of very essential problems in fusion research. This has been made possible by an extremely well organized participation in world leading tokamaks, mainly JET and ASDEX Upgrade in Europe, but with contributions also to DIII-D (USA), KSTAR (Korea), T-10 (Russia) and HL-2A (China). FOM is renown for its world leading role in diagnostic development. As these new diagnostics allow very often for interesting new physics investigations and deeper understanding, FOM is extremely welcome to participate in the above mentioned tokamak experiments. Recent highlights are in particular

- the suppression of tearing modes using the in-sightline feedback system at TEXTOR, where it was possible to separate the plasma signal (nW range) from the ECRH radiation (MW range).
- the development of an ECE imaging system that allowed for high resolution, two-dimensional temperature measurements, providing thus new insight into the physics involved in MHD instabilities, e.g. in forced reconnection events during sawtooth crashes (TEXTOR), ELMs and fast particle driven instabilities (ASDEX Upgrade).
- the ground breaking upgrade of the Thomson scattering system to one providing very high repetition rate and high radial resolution

This expertise is being used to support the diagnostics developments for ITER: Within the ITER NL consortium FOM is involved in the design of two Upper port systems of ITER: a Charge Exchange Recombination Spectroscopy (CXRS) and a launcher for Electron Cyclotron waves. FOM is leading the corresponding consortium for the ITER Electron Cyclotron Heating System (ECRH). In addition, FOM is involved in the development of the core Thomson scattering system.

The work of the computational plasma physics group is well aligned with the experimental activities, focussing e.g. on wave physics and the influence of ECRH on MHD stabilities.

This positive overall assessment is consistent with the publication statistics presented. The Fusion Physics group overall has an average impact above the international level impact. The diagnostic group, in particular, has a remarkably high impact, reflecting its leading role world- wide.

In addition to the scientific work, the fusion physics group has been very active in public outreach. The fusion road show – a FOM invention – was a great success, and sets an example on how the public can be informed about the scientific work in this field and its potential role in a future energy mix.

Future perspective

The group rightly sees its future in strong international collaboration, providing diagnostics for the world leading fusion devices. That way, the group will always be welcome at these devices and will achieve first-class physics results. FOM is one of the few laboratories that were able to achieve excellent experimental results without a national fusion physics device. Given that on the way to ITER and a fusion reactor, future work will have to concentrate on joint exploitation of only very few devices, FOM sets already a prime example on how excellent science with visibility for the home lab can be achieved in the very international collaborative work. FOM's role in developing diagnostic systems for ITER is exceptional for such a relatively small institution. Similarly remarkable is that FOM is leading the European consortium to provide the ECRH system for ITER.

Recommendations

- Keep the world leading role of the diagnostics group by providing sufficient funding. The budget for the Fusion Physics division needs to be increased by 200 k€ to maintain the current strength and high productivity of this effort.
- Continue the successful collaboration, in particular with the world leading experiments to make use of the excellent diagnostic developments in the institute.
- Concentrate the theory/computational activities on those topics where FOM has particular expertise. As the mission of the division is the 'control of MHD modes and fast particles', the theoretical activities in the field of fast particle physics should be strengthened.

4.2 Research programme of the Plasma Surface Interaction division

Current research programme leader:	Juergen Rapp / Richard van de Sanden a.i.
Tenured staff:	4
Other personnel (end 2010):	1,3 Postdocs, 7 PhD-students, 10 Technical Staff
Publications (2006-2010):	95

Quality	5
Productivity	4,5 (but improving)
Relevance	5
Impact	4 (but improving)
Vitality	5
Overall	**4,5**

Overall assessment

Choosing plasma surface interactions (PSI) as one of the key development directions for the Institute, FOM has taken a very strong orientation, which targets one of the key issues for the development of fusion energy. Moreover, the decision to build a unique device, i.e. a plasma-surface interaction simulator as Magnum PSI should be considered as both original and very clever. Up to now, plasma wall interactions simulators, while providing strong insight into plasma wall interactions physics, failed to reproduce a combination of parameters (plasma density and temperature, but also relevant plasma facing components) so as to mimic PWI in fusion devices. This appears now very complimentary to experiments achieved in fusion devices, at the expense of the burden to develop and then operate the device. It should be noted that success has been delayed; however, the development of Pilot-PSI proved to be extremely efficient by allowing at the same time to open the way to the production of the expected high density plasma, while producing interesting physics studies such as displayed within the report. The capability to operate Magnum very soon with copper coils at half maximum field, before the superconducting coils problems can be fixed will allow a prompt implementation.

The flexibility of the division is not only given evidence in the process of MAGNUM PSI development but also through an adaptation to the top issues of concern for ITER divertor, including the choice of tungsten as plasma facing material for ITER divertor in its nuclear performing phase. Another synergistic development deals with adequate up to date diagnostics for both plasma and plasma wall interaction processes characterisation.

Two groups within the division are more in charge of investigating the physics of low temperature plasmas and plasma wall interactions either experimentally or by modelling. Many interesting results have been achieved, including the ones leading to better understanding and finally improvement of the devices. However, the large number of selected topics appears as rather high in view of the relatively scarce number of scientists, either permanent or temporary. The efforts in theory and modelling would get more impact if well aligned with defined problems.

The number and quality of the publications, even if not achieving records obtained in other divisions is very satisfactory, as it has to take into account the supposed large effort which has to be devoted to Magnum PSI construction. Nevertheless a strong increase was recorded in the last two years, which should be highly commended. The collaborative effort seems to be quite high but does not appear so clearly in the outputs of the division. Similarly, one would have expected to learn more from the synergy with activities performed in similar fields within the trilateral EUREGIO Cluster.

Future perspective

The prospects of the division are very good, once they can draw the best output from Magnum PSI. The dominant goal of "fundamental understanding of the Physics and Chemistry of the Plasma Surface Interaction and Material Science for solving the Plasma facing Material Problem in Future Fusion Reactors" should obviously be commended. The division has developed both in house and also through collaborations the full conditions needed to develop this ambitious goal, and thus even more as Magnum PSI will be a unique tool at least in Europe for such studies. However, a complementary development may also be envisioned where divertor plasma operation could be studied, by studying in a more versatile way than in a tokamaks some operational issues such as in situ monitoring of plasma facing components either during plasma operation or in between plasma pulses (erosion, dust formation measurements etc…). In that respect the relocation of the laboratory within a multidisciplinary important University (within a very active industrial area) such as Eindhoven, yield even more assets to the PSI division.

Recommendations

- Develop MAGNUM PSI as a flexible facility with a capability to host external collaborations.
- Develop complementary programme between MAGNUM PSI and actual experimental programme in fusion devices
- Bring even more connexions to efforts in integrated modelling in view of ITER preparation, and concentrate the modelling activity of number of selected questions.

4.3 Research programme of the Nanolayer Surfaces and Interface Physics division

Current research programme leader: Fred Bijkerk

Tenured staff:	10,1 (5 Technical staff, 5.1 Scientific staff)
Other personnel (end 2010):	17,2 (3,7 Postdocs, 9,6 PhD-students, 3,9 Technical staff)
Publications (2006-2010):	Papers 52, Patents 20

Quality	5 (world leading, internationally renowned)
Productivity	5 (patents, papers, and prototype optics); 4,5 on papers only.
Relevance	5
Impact	5 (valorisation)
Vitality	5 (experimental facilities)
Overall	**5**

Overall assessment

The division conducts a world leading programme in the field of thin film and interface physics. It is truly multidisciplinary, including photochemistry, plasma physics, and short wavelength optics, and it has a strong application focus on multilayer optics for advanced short wavelength radiation sources. While the emphasis is on the basic physics, the division demonstrates continuously the applicability of its discoveries. The main application is in the heart of new generations of photolithography machines for the fabrication of integrated circuits. Intimate collaboration exists with optics manufacturer Carl Zeiss and the producer of lithography equipment ASML. Basic understanding of the physics of thin film and multilayer has lead to improved control of surface and interface chemistry resulting in world record reflectivities, for instance.

The other application is in optics for free electron laser radiation. The realisation of a unique beam splitter for short wavelength radiation based on a stress free multilayer structure, deposited on a thin film membrane, is an example which was received enthusiastically by the free electron laser user community.

Next to the programme focussing on the design and growth of multilayer optics, another programme focuses on the processes of degradation during the usage of the optical elements. It deals with issues like diffusion on extreme small scales to be able to predict lifetime of the optical elements on a macroscopic scale. It also involves in-situ monitoring of contamination at unprecedented low levels. A new industrial partnership programme addresses these photon and plasma induced processes at EUV optical surfaces.

From the start in 1987, the multilayer optical components activities have steadily grown, and are now largely funded through external, mostly industrial contacts. Advanced deposition coaters, combined with all the relevant in-situ analysis facilities, guarantee the continuation of the position as leader in the field of reflective optics for EUV, and the delivery of the highest reflectivity optics to industry.

The division produces an impressively increasing output of papers, patents and prototype optics, starting from a relatively modest level in the beginning of the evaluation period. Fred Bijkerk won the 2010 FOM valorisation price for the activities of his division.

The number of patents is very high, in particular related to the number of staff involved. The division has generated almost all patents of the institute. The division also produces prototype optics, continuously improved along with the progress of the development of the associated physics.

Future perspective

The multilayer programme for XUV has evolved to a level of maturity where the emphasis has shifted from design and manufacturing of multilayer optics to the understanding of degradation processes during their usage. A substantial industrial partnership programme with Carl Zeiss and ASML is in place for studying processes at XUV optical surfaces for the next 5 years. In addition, a variety of funding schemes and the commitment of industrial partners is in place for more advanced thin film optics, such as needed for soft X-ray end XUV free electron lasers, ensuring the continuation of the research over a number of years.

Within the framework of 'Science for future energy' a new experimental facility has been built to investigate surface reactions on catalytic materials for photo conversion. It allows fundamental surface science studies of photochemical reactions relevant for the synthesis of solar fuels. This line of research fits seamlessly in DIFFER.

Recommendations

We encourage the group to continue along the two lines that have emerged from the nanolayer surface and interface physics programme.

The first line, dealing with multilayer optical elements, would not fit in DIFFER. It would be worthwhile to consider a spin out of the activities into a start-up company for the design, development, and production of multilayer short wavelength optical elements. It seems that the research programme has achieved the required level of maturity.

The other line of research, dealing with fundamental aspects of photochemical reactions on catalytic surfaces, will find a fruitful breeding ground in DIFFER. The group has an excellent position to realise breakthrough materials and material processes for solar fuel.

4.4 Research programme of the Generation and Utilization of THz radiation division

Current research programme leader:	Lex van der Meer
Tenured staff:	6
Other personnel (end 2010):	10,8 (0,4 Postdocs, 3,6 PhD-students, 6,8 Technical Staff)
Publications (2006-2010):	143

Quality	5
Productivity	5
Relevance	5
Impact	5
Vitality	5
Overall	**5**

Overall assessment

The Division operates with the objectives of offering the international community access to a bright tunable radiation source in the 3 to 250 micron range, running a molecular physics research effort aimed at structure and dynamics of complex molecules, ions and clusters in the gas phase, and offering opportunities for research in solid state physics and ion spectroscopy of biomolecules. This research effort is to be highly commended for establishing a robust and vital research programme from a quite modest facility base. The programme is perhaps the most productive long wavelength FEL photonics research effort in the world with a sizeable portfolio of interesting publications and significant contributions in a number of technical areas. The development of the FELICE beamline for intracavity enhancement of intensity along with the molecular beam apparatus and Fourier Transform Ion Cyclotron Resonance mass spectrometer has been a major capability addition paying off handsomely in terms of research output. While most of the FEL world has focussed on producing hard x rays at major facilities in huge programmes spending > M€ 500 on staff and infrastructure, this group has aimed their effort at the vital science enabled by a unique light source. The cost of this effort has been modest, on the order of 1 to M€ 1,5. Taking advantage of high powers, tunability, and operation in wavelength ranges inaccessible through other means the group has consistently produced a significant research output as evidenced by publication quantity, quality, and impact (for the Division a CPP without self citation of 9,32!). Especially in the molecular dynamics area the impact factor is quite significant with an MNCS of 1.63 for the 2005-2009 period. Although the impact of FELIX and FELICE papers is somewhat low at MNCS of 0,66 in a profile of high impact journals this probably reflects the immediate focus of the FEL field on major x ray sources rather than any shortcoming of staff efforts.

The training of technical staff in the field has also been quite successful producing a continuing output of PhDs with a comprehensive skill set in the relevant technologies and techniques. In their niche of long wavelength operation this work is world leading and the overall operation of the facility is a model for how to mount a successful programme on modest resources. In addition to the key research results in the long wavelength regime they have had good results in supporting the technology efforts of the major programmes such as FLASH by applying their substantial technical expertise in accelerator technology to perform bunch length diagnosis among other contributions.

The facility experienced a fire in 2006 which temporarily reduced the productivity. In part this was due to a user serving as a (relatively inexperienced) operator. The lesson was learned and now operations are performed by trained staff. This is a good approach for safe operation which should be continued in the new FLARE combined operation.

Future perspective

The group has taken on a very forward-looking strategic move with the transfer of the THz radiation programme to the Institute for Materials and Molecules at the University of Nijmegen merging with the FLARE FEL facility. The Institute combines several active areas of which complement the historical areas of interest at FELIX which will benefit from the synergy of multiple technical drivers. The trend of increasing utilization and growth of long term user groups is expected to continue at Radboud University. The longer wavelength focus of FLARE will complement research in spectra of strongly bound ions, metal clusters, far-IR dissociation spectroscopy of peptides and proteins and time resolved pump-probe research. There will be net cost savings in the new Institute due to the availability of experienced staff and extra equipment as well as the elimination of duplicate overhead functions. In all it is an advantageous strategic alliance for both groups and should serve to establish a firm footing for the THz programme (FOM/RU) for years to come. We congratulate the leaders of the THz programme in identifying this solution and establishing a firm future for this effort. In the absence of such an ambitious plan it is possible that the future of this excellent research programme would have been in doubt. Instead it should experience healthy growth and a continuing vital contribution to research in the FIR field.

Recommendations

We encourage the group to follow through with the move to the new research Institute incorporating such machine improvements and other additions to capability as are feasible during the move. Apply your experience in support of the new group in re-commissioning the FELIX and FELICE systems. Further the experience of the FELIX group in operating for over a decade will provide a substantial benefit in the commissioning and operation of all the other new systems at FLARE allowing a much shortened time to delivery of high quality, high reliability beam to users. As the FELIX group has learned, establishment of a successful research programme is much more than simply providing an operational light source.

Additional optics and diagnostics capability and incorporations of supporting instrumentation and staff support are essential to deliver cutting edge results in today's research environment. The experience and successful research record at Rijnhuizen should serve to launch the new enterprise with much more vigour than might be expected from a green field site.

4.5 Education and outreach

Overall Assessment

PhD students play key roles in scientific research, as colleagues carrying out the research programme and as protégés who will grow into the next generation of researchers. The education of Ph.D. students at FOM Rijnhuizen is organised thoroughly to insure the quality of research and professional experience of the students. Each student works under a scientist holding a joint appointment at a Dutch university and enjoys the guidance of a separate senior member of the Institute research staff. During the student's first year, special attention is paid to his thesis topic, to ensure that it can be completed successfully within four years; if it is judged to have a low probability of completion, it is terminated within one year. Students are given courses in applications of research and required to include a chapter in their thesis on societal benefit of their research, training not common at other institutions. FOM Rijnhuizen is to be commended for its well-designed and effective programme for educating PhD students.

The majority of PhD students go on to research positions at the postdoctoral level, but a significant number enter industrial research positions, thus contributing powerfully and personally to technology transfer. The number of PhD students is low, considering the number of permanent and visiting scientists at FOM Rijnhuizen. A larger number would significantly enhance the atmosphere and the productivity as envisioned by the new Director.

The outreach programme to industry, to ITER and to the public is excellent. FOM sponsors a valorisation prize, formally indicating its strong support of outreach and encouraging staff members to make creative outreach efforts; Fred Bijkerk won this prize in 2010 for the contributions of nSI to EUV optics. Also Tim Tsarfati, a PhD student in the NSI division won the valorization chapter prize in 2009. The valorisation officer at Rijnhuizen investigates opportunities for industry use of Rijnhuizen research and promotes ties between the Institute and industry. Rijnhuizen supplies the Dutch industrial liaison officer to Fusion for Energy, the European coordinating agency for fusion and promotes participation of Dutch companies in the ITER programme. The connection of FOM Rijnhuizen to optics firm Carl Zeiss and lithographic equipment producer ASML are quite strong in the area of multilayer extreme ultraviolet (EUV) optics produced by the nanoscale Surface and Interface Division (nSI). The Public Information group encourages young students to take up science as a profession, provides guided tours of the Institute, organizes open houses and arranges interviews with Institute scientists. The Public Information group coordinated the implementation of FUSENET, aimed at improving education on fusion in Europe. Especially impressive is the Fusion Road Show, an interactive multimedia performance for audiences at all levels from primary school to adults. During the evaluation period, the Fusion Road Show participated in 17 large public events such as the World Scouting Jamboree in 2007 and the Lowlands Music Festival in 2010. Finally, the Public Information group wrote and distributes a 60-page booklet, 'Energy, Powering Your World' available in six languages. This aggressive, resourceful and successful programme of public outreach is exemplary among research institutes.

Future Perspectives

The opportunities for PhD education will be dramatically greater after the addition of Solar Fuels to the research agenda and the move to TU/e, with a ready source of students and many related research opportunities. Solar Fuels, in particular, is a topic of strong interest to many students and the public, offering additional opportunities beyond fusion for outreach to the general population.

The opportunities for public and industrial outreach will expand significantly with the addition of Solar Fuels to the research programme and the coordination role of DIFFER in coordinating energy research. DIFFER will be able to educate at all levels, not only about fusion, but also about all kinds of alternative energy. There are ample opportunities for coordination with the European Technology Plan and for informing the public through programmes tailored for primary and secondary school programmes and for the general population.

Recommendations

- DIFFER should take advantage of the addition of Solar Fuels and the move to TU/e to significantly increase its education of PhD students, keeping the same high standards for their mentoring and for the viability of their thesis projects.
- The strong and effective programme of public education at all levels developed by FOM Rijnhuizen should continue and expand to include Solar Fuels and the importance of other kinds of alternative energy sources and uses. The topic of energy is of high interest to the public and is likely to remain so for many years; it is a prime opportunity to reach out to the students, adults and future decision makers to present the importance to society of energy and its scientific development. DIFFER should use its considerable knowledge and experience in public education to make the most of this opportunity.

4.6 Knowledge transfer

The internal and external communication processes of the institute are excellent, exemplified by a variety of activities in the field of industrial collaboration, the transfer of scientific results to the public domain, and valorisation. The institute produces 4 patents per year. Fred Bijkerk, head of the division of nanolayer Surfaces and Interface physics, won the 2010 valorisation price. Technology transfer of fusion research is very well organised in the consortium ITER-NL, where contacts are established with many Dutch companies involved in the development of essential components. Research on plasma surface interaction at high fluxes is capitalised for the next generation of photolithography and X-ray free electron lasers. Contacts are established with numerous international institutions that employ the free electron laser at Rijhuizen.

In addition to contacts with the high tech industry, the institute maintains excellent contacts with 7 universities by having staff members as part-time professors. Lastly, there is a close cooperation with the applied science and technology institutes TNO and ECN.

5 Conclusions and Recommendations

By all measures, namely scientific and technical success of its programmes, productivity and reputation of its scientific programme and staff, training of PhD students, technology transfer and valorization, the Rijnhuizen Institute has enjoyed a remarkable period of achievements during the past 6 years.

A few highlights (many more are cited in the report)

- Development of advanced diagnostics for fusion plasmas, with application to TEXTOR and ASDEX UG leading to new understanding of complex MHD instabilities;
- Use of advanced control techniques (in collaboration with Eindhoven) to suppress tearing modes in TEXTOR;
- Development of ITER NL, providing Dutch industry with access to potential ITER contracts and assuring lead roles for Dutch physicists in implementing (and ultimately operating) a CXRS diagnostic and collaborative roles in electron cyclotron stabilization experiments;
- Development and operation of the FELIX/FELICE facility, perhaps the most productive long wavelength FEL photonics research effort in the world with a sizeable portfolio of interesting publications and significant contributions in a number of technical areas;
- Development of multilayer optics for advanced short wavelength radiation sources, enabling a new generation of photolithography machines for the fabrication of integrated circuits.

The Panel shares the Institute's disappointment with the delay in the completion of the Magnum PSI project but applauds the measures that were taken to achieve operation before delivery of the superconducting magnets. The panel notes that the importance of the project remains as strong as it was when it was first conceived. The Panel congratulates the PSI-team for the excellent results already obtained with Pilot PSI.

The Panel notes a welcomed increase in both the number of PhD students and publication rate, particularly in the last year. This is especially gratifying in view of the recommendation to this point made in the 2008 Evaluation.

Looking forward, the Institute is transforming itself to be better aligned with a 'Science for Future Energy' theme. This will result in divesting the GUTHz and much of the nSI Divisions, and replacing them with two new Solar Fuels divisions: Materials and materials engineering for Solar Fuels (MaSF) and Devices and processors for Solar Fuels (DeSF). The move to align the fusion research effort along well selected axes prioritising the ITER scientific needs should be continued.

The re-direction of the mission of FOM Rijnhuizen is an appropriate and well-timed response to societal needs for clean and secure energy supplies in the future. The menu of choices for alternative energy is diverse and it is too early to know which options will turn out to have the right combination of cost, cleanliness and capacity for the Netherlands. Given this uncertainty and the need for fundamental and applied science to understand and control the phenomena of alternative energy, a continuous process of strategic evaluation and investment is needed. FOM Rijnhuizen is well-placed to take on a coordinating role, seeking advice from industrial partners and researchers, partnerships with industry, and advising FOM and NWO of the best strategic research investments. The Panel suggests that the Institute undertake this role with care, so that it is viewed as enabling a programme of coordinated research.

Solar Fuels is an appropriate choice for DIFFER's contribution to non-fusion energy research. Solar Fuels is rich in opportunity for renewable production and storage of energy and comprises many still-mysterious static structures and dynamic processes that require fundamental science to understand and control. The panel notes that the fundamental challenges of solar fuels make its deployment at least a decade (and perhaps much more) away. This long time to deployment should be balanced by other energy technologies that have potentially shorter deployment horizons. Overall, the panel finds this to be a bold, high-risk, high-payoff undertaking. High risk because of the high productivity the Institute is giving up in divesting the GUTHz and much of the nSI divisions, uncertainty in the most profitable technical directions to pursue, and the time it will take to build up the necessary expertise; high payoff in view of the magnitude and impact of the potential contribution it can make to the practical realization of solar fuels.

The launching and development of two excellent divisions (GUTHz and nSI) are a testament to the creativity, energy and vitality of FOM Rijnhuizen. These groups are recognized leaders in their fields. They and the Institute should take credit for creating and nurturing such effective programmes and for contributing them to Dutch academic and industrial enterprise.

An additional aspect is the move of the newly named DIFFER Institute to the campus of the Eindhoven University of Technology, which will undoubtedly enhance the educational component of the Institute's mission as well as providing a fertile and stimulating environment for growth of the new Solar fuels divisions

6 Appendices

6.1 Curricula vitae of the committee members

Ron Parker (Chair), Professor,
Departments of Electrical Engineering and Nuclear Science & Engineering, MIT

Professional Experience

Dr. Parker is a Professor in the Departments of Electrical Engineering and Nuclear Science & Engineering at MIT. He joined the Electrical Engineering Faculty in 1967 and carried out basic plasma physics experimental research on feedback stabilization of drift-type instabilities and parametric excitation of waves in beam-plasma systems. In 1973 he became head of the Alcator A experiment and led the international team that achieved, for the first time in a laboratory, confinement sufficient for fusion energy breakeven at fusion-relevant temperatures, ($n\tau$ >6x1019 s/m^3 @ T ~ 1 keV.). Dr. Parker then led the design, construction and operation of the follow-on device, Alcator C. A notable result from this device was the discovery that peaking the density profile using pellet fueling improved confinement by stabilizing Ion Temperature Gradient modes, which continue to play an important role in tokamak confinement today. Alcator C set new records for confinement performance which it held until the large tokamaks JET, TFTR and JT-60 came into operation. In 1986, Dr. Parker became head of the physics team designing the Compact Ignition Tokamak at Princeton Plasma Physics Laboratory. He returned to MIT in 1987 and became Director of the Plasma Fusion Center, a position he held until 1995. In 1992, he took leave from MIT to become Associate Director of ITER and Head of the European ITER Design Center in Garching, Germany. There, he was responsible for the design of ITER's internal components including the vacuum vessel, divertor, first wall and blanket, and RF heating and current drive systems. Dr. Parker returned to MIT in 1998 and resumed experimental work on Alcator C-Mod where he currently leads a group studying RF Current Drive in the Alcator C-Mod device. In this experiment, over 1 MW of power at 4.6 GHz is coupled to C-Mod plasmas, and ~ 800 kA of current has been driven. New discoveries are being made with the use of this tool in combination with advanced simulations. An upgrade is underway that will at least double the amount of available power in 2012.

Dr. Parker has served on a number of advisory committees including the Princeton Plasma Physics Laboratory Advisory Committee (Chair), the Max-Planck Institut für Plasma Physik Fachbeirat (Chair), the DIII-D Programme Advisory Committee (Chair), the European Fusion Facilities Review, the CEA Conseil Scientifique du DRFC, and the NRC Burning Plasma Advisory Committee. He has received the APS Excellence in Plasma Physics Award, the ERDA (now DoE) Distinguished Associate Award and the Fusion Power Associates Leadership and Distinguished Career Awards. He is a member of the National Academy of Engineering and a Fellow of the American Physical Society.

George Neil

Dr. Neil (BS, Engineering Science, U. Va., (1970); MS, Nuclear Engineering, U. Wis., (1974), Ph.D., Nuclear Engineering, U. Wis., (1977)) is Associate Director of Thomas Jefferson National Accelerator Laboratory with responsibility for the Free Electron Laser Division. He directs the development of the Free Electron Laser systems and supports the user operation of the facility for basic and applied research. Prior to this assignment he served as Linac Department Manager at CEBAF where he had responsibility for designing, installing, commissioning, and maintaining the linear accelerator systems including injectors, RF systems, and cryogenics comprising > $100M budgets. The RF systems include over 340 high power RF sources each with microprocessor control. The Cryogenic system includes the world's largest 2K helium refrigerator. Prior to coming to CEBAF in 1970 he was employed from 1977 to 1990 by TRW, Defense and Space Systems Group as Chief Scientist on the Induction Free Electron Laser Programme at Lawrence Livermore National Laboratory.

Professional Activities

- Editor, *Infrared Physics and Technology* 2003-2007
- Editorial Board*, Journal of Infrared Millimeter and Terahertz Waves* 2009-Present

Served on Programme Committees for 1987, 1988, 1989 International FEL Conferences; 1989 CLEO/QLES Conference, 1987 IEEE Particle Accelerator Conference, 2003 IEEE Particle Accelerator ConferenceLinac94, Linac96, Linac98, Linac2000, Linac 02. Served on the FEL International Executive Committee since 1993. Chairman of the FEL International Executive Committee, Chair of the 20th International Free Electron Laser Conference held in Williamsburg, VA, August 17-21, 1998. Member of the International Executive Committee of IRMMW-THz Conferences since 2000. Reviewer for DOE and NNSA Projects including the development of the LCLS X-ray Laser and the National Ignition Facility at Lawrence Livermore National Laboratory, and NSLS-II at Brookhaven. He has advised Daresbury Lab (England), FOM (Netherlands), and Bi-national NSF efforts with Israel.

Selected Patents, Honors, etc.

- 13 Patents awarded in Free Electron Lasers, accelerator technology, optics, and plasma physics.
- Co-Winner (with S. Benson): Year 2000 International FEL Prize
- Fellow of the American Physical Society Division of Beams
- Fellow Directed Energy Professional Society
- Co-recipient, R&D Magazine R&D 100 Award for 'The Tunable Energy Recovered High Power Infrared Free-Electron Laser' as one of the 100 most technologically significant new products of 2005.

Key accomplishments (with team members from TRW, Stanford University, and Jefferson Lab):

- the first measurement of optical beam quality in an FEL, first oscillation of a tapered wiggler FEL, first visible lasing from a linac-driven FEL;
- the first demonstration of same cell energy recovery in an FEL, the highest power production of any FEL by more than three orders of magnitude, and
- demonstration of the highest power by 10,000x of broadband terahertz in picosecond pulses.

Thijs Viegers

Dr. Viegers was Chief Technology Officer at Philips Applied Technologies, and has been with Royal Philips Electronics for over 30 years in a number of key positions. He was leading the new technology development and new business development for contract R&D. Philips has adopted a strategy of Open Innovation to leverage the joint innovative power of partnering companies and researchers and bring more innovations to the market faster and with greater efficiency.

Dr. Viegers has a Masters in chemistry, a PhD in physics and a broad background in materials science. His assignments with Philips Electronics have included responsibility for product development, process development, and the development of the associated equipment. The applications have covered innovative breakthroughs with passive components (ceramic capacitors), semiconductor devices and modules (digital and analog IC, LED, laser, camera, and radiation detectors), molecular diagnostic modules (lab-on-a-chip), energy modules (PC, CPV, fuel cells), and high precision processing equipment (printing, lithography, interconnect and packaging, assembly and inspection).

André Grosman, Institute Deputy Head

CEA/Direction des Sciences de la Matière/Institut de Recherches sur la Fusion par confinement Magnétique (Magnetic Fusion Research Institute).

Diplomas

Engineer from Ecole Centrale des Arts et Manufactures, Paris (1980).
Post graduated in statistical Physics from Paris VI-Jussieu University (1980).

Professional experience

Mr. A. Grosman started is career as engineer physicist at the Département de Recherches sur la Fusion Contrôlée (Euratom CEA) in December 1981 at Fontenay-aux-Roses then at Cadarache. He first investigated scrape off layer physics of the TFR tokamak and installed a pump limiter in that tokamak. After moving to Cadrache, where CEA had decided to build the Tore Supra tokamak; he then became Plasma-Wall Interactions Group Leader from 1986 to 1998 while being responsible of edge plasma diagnostics on Tore Supra (1986 to 1998), involving design, manufacturing, assembly and installation (fast moving Langmuir probes and other probes), and leader of ergodic divertor experimental studies in Tore Supra tokamak (1989-1998). He was also project leader of the ergodic divertor upgrading on Tore Supra (1994-1996), involving design, manufacturing, assembly and installation of inertially and actively cooled facing components. His programme management activities included being Tore Supra Programme Leader in 2001 and 2004.

He was appointed as plasma wall Integration division head (CEA/DSM/DRFC/SIPP) from October 1st 1998 to November 1st 2008. The division was responsible of Plasma Wall Interactions physics studies and of Plasma Facing Components (PFCs) technological developments, in addition to the CAD office, including the full Tore Supra refurbishments with actively cooled PFCs achieved in 2002 (CIEL project). He is since November 2008 Fusion Research Institute deputy head. A. Grosman published up to now about 200 papers.

Mr. A. Grosman as served in a number of committees, including the JET Scientific Council (1991-1998), the European Fusion Development Agreement (EFDA) Scientific and Technical Advisory Committee (2002, 2004-2008), the Plasma Physics and Controlled Fusion Editorial Board (1998-2005). He was appointed as Chairman of the Steering Committee of the French Féderation de Recherches sur la Fusion par confinement magnétique (CEA, CNRS, INRIA, and 6 French Universities) (2007-2011) and sits now within the Fusion for Energy (F4E) Technical Advisory Panel (2010-).

Recent achieved expertise were achieved by him as member of the Working Group 8 (Plasma facing components) of the ITER Design Review (2007), member of the F4E ITER Cost Assessment Task Force (2008), Member of F4E tungsten divertor assessment Group (2009), and Chairman of ITER Blanket Conceptual Design review (2010).

George Crabtree

George Crabtree is Distinguished Professor of Physics, Electrical, and Mechanical Engineering at University of Illinois at Chicago and Senior Scientist and Distinguished Fellow in the Materials Science Division at Argonne National Laboratory. He has won numerous awards for his research, most recently the Kammerlingh Onnes Prize in 2003 for his work on the physics of vortices in high temperature superconductors. This prestigious prize is awarded once every three years; Dr. Crabtree is its second recipient. He has won the University of Chicago Award for Distinguished Performance at Argonne twice, and the U.S. Department of Energy's Award for Outstanding Scientific Accomplishment in Solid State Physics four times, a notable accomplishment. He has an R&D 100 Award for his pioneering development of Magnetic Flux Imaging Systems. He is a Fellow of the American Physical Society, a charter member of ISI's Highly Cited Researchers in Physics, and a Member of the U.S. National Academy of Sciences.

Dr. Crabtree has served as Chairman of the Division of Condensed Matter of the American Physical Society, as a Founding Editor of the scientific journal Physica C, as Divisional Associate Editor of Physical Review Letters, as Chair of the Advisory Committee for the National Magnet Laboratory in Tallahassee, Florida, and as Editor of several review issues of Physica C devoted to superconductivity. He has published more than 400 papers in leading scientific journals, has collected over 15,000 career citations, and has given approximately 100 invited talks at national and international scientific conferences. His research interests include materials science, sustainable energy, nanoscale superconductors and magnets, vortex matter in superconductors, and highly correlated electrons in metals. He has led workshops for the Department of Energy on hydrogen, solar energy, superconductivity, materials under extreme environments, basic science for energy technology, and computational materials and chemistry for economic competitiveness. He co-chaired the Undersecretary of Energy's assessment of DOE's Applied Energy Programmes. He has testified before the U.S. Congress on the hydrogen economy and on meeting sustainable energy challenges.

Sibylle Günter

Scientific Director of the Max-Planck Institute for Plasma Physics Garching, Greifswald, Germany

Sibylle Günter graduated in physics at Rostock University in 1987 and was awarded her PhD three years later. Her subsequent studies as scientific assistant at the University of Rostock were intensified by periods of research in the USA at the University of Maryland and the National Institute of Standards and Technology. In 1996 she gained her lectureship qualification at the University of Rostock with a thesis entitled 'Optical Properties of Dense Plasmas'. In the same year she joined IPP at Garching. In 2000 she was appointed a Scientific Fellow oft he Max-Planck society and became head of IPP's Tokamak Physics Division at Garching.

Since 2001 she has been lecturing as Associate Professor at the University of Rostock, and since 2006 been Honorary Professor at the Technical University of Munich. In February 2011 Sibylle Günter has taken up her appointment as Scientific Director of Max Planck Institute for Plasma Physics (IPP) at Garching and Greifswald. Sibylle Günter is Professor of Theoretical Physics. Her research field is theoretical plasma physics, her main areas being magneto-hydrodynamics and kinetic theory of supra-thermal particles.

Memberships/Reviewer

International Fusion Research Council (IFRC) of the International Atomic Energy Agency (IAEA) (2004-), steering committee of the European Fusion community (EFDA steering committee (2008-, chair 2011), Chair of the International Tokamak Physics Advisory Committee on Energetic Particle Physics (2008-2010), Chair of the board for high-performance computing of the European fusion community (2008-2010), Member (2004-2006) and Chair (2006-2008) of the plasma physics section of the German Physical society, Member of the scientific advisory committee of the Princeton Plasma Physics Laboratory PPPL, USA (2009-); member of the DIII-D programme committee, San Diego, USA (2006-2008), Member of the ERC panel starting grants (2009-2011), reviewer for German Research Foundation, Finland Academy of science, DOE (US), EURATOM, Danish National Research Foundation, Spanish Ministry of Science and Innovation, Member of the programme committees of European Physical society, plasma physics conference (2006, chair, 2007), the European Fusion Theory conference (2000-2009), the IAEA Technical meeting on 'Theory of plasma instabilities' (2002-), the IAEA Technical meeting on 'Energetic particle physics' (2007- chair, 2007)

6.2 Programme of the site visit 28-30 September 2011

Wednesday, 28 September 2011

Location: **Grand Hotel Karel V, Utrecht**

17.00 – 17.15	Welcome and introduction by Dr. ir. W. van Saarloos, director of FOM
17.15 – 17.30	Installation by Prof. dr. B. de Kruijff, member of the General Board NWO
17.30 – 17.45	Introduction of FOM in Dutch context and developments by Dr. ir. W. van Saarloos
17.45 – 18.15	General introduction to FOM-Rijnhuizen (past and future) by Prof. dr. ir. M.C.M. van de Sanden, director of Rijnhuizen
18.15 – 19.00	Internal discussion of panel, division of tasks (closed session)
19.00	Diner in 'Brasserie Goeie Louisa', panel with De Kruijff en Van Saarloos

Thursday, 29 September 2011

07.30 – 08.15	Taxi from Grand Hotel Karel V to Rijnhuizen
08.15 – 08.30	Welcome

PAST PERFORMANCE

FUSION PHYSICS

08.30 – 08.40	Introduction by panel discussion leader: Prof. dr. S. Günter (closed)
08.40 – 08.50	Introduction by division head – Prof. dr. A.J.H. Donné
	Presentations: *7 min + 8 min discussion (panel and presenter, excl. division head)*
08.50 – 09.05	Dr. P. de Vries – Plasma Diagnostics
09.05 – 09.20	Prof. dr. M. de Baar – Tokamak Physics
09.20 – 09.35	Dr. E. Westerhof – Computational Plasma Physics HT
09.35 – 09.50	Prof.dr. A.J.H. Donné – ITER-NL
09.50 – 10.05	Panel discussion (closed)
10.05 – 10.15	Break

PLASMA SURFACE INTERACTIONS

10.15 – 10.25	Introduction by panel discussion leader: Prof. dr. A. Grosman (closed)
10.25 – 10.35	Introduction by division head – Dr. J. Rapp
	Presentations: *7 min + 8 min discussion (panel and presenter, excl. division head)*
10.35 – 10.50	Dr. P. Zeijlmans van Emmichoven – Plasma Surface Interactions – Operations
10.50 – 11.05	Dr. G. van Rooij – Low Temperature Plasma Physics and Heating
11.05 – 11.20	Dr. G. de Temmerman – Plasma Surface Interactions – Experimental
11.20 – 11.35	Prof. dr. W. Goedheer – Computational Plasma Physics LT
11.35 – 11.50	Panel discussion (closed)

GENERATION AND UTILIZATION OF THZ RADIATION

11.50 – 12.00	Introduction by panel discussion leader: Prof. dr. G. Neil (closed)
12.00 – 12.10	Introduction by division head – Dr. A.F.G. van der Meer
	Presentations: *7 min + 8 min discussion (panel and presenter, excl. division head)*
12.10 – 12.25	Dr. B. Redlich – FELIX/FELICE
12.25 – 12.40	Prof. dr. J. Oomens – Molecular Dynamics
12.40 – 12.55	Panel discussion (closed)
13.00 – 14:00	Working Lunch (panel and division leaders)

NANOLAYER SURFACE AND INTERFACE PHYSICS

14.00 – 14.10	Introduction by panel discussion leader: Prof. dr. T. Viegers (closed)
14.10 – 14.20	Introduction by division head – Prof. dr. F. Bijkerk
	Presentations: *7 min + 8 min discussion (panel and presenter, excl. division head)*
14.20 – 14.35	Dr. A. Yakshin – Physics of Thin Films and Multilayers
14.35 – 14.50	Drs. E. Louis – Advanced application of XUV Optics
14:50 – 15.05	Prof.dr. F. Bijkerk – Surface Ion and PhotoChemistry
15.05 – 15.20	Panel discussion (closed)
15.20 – 15:30	Break
15:30 – 16:00	Dr. W.R. Koppers – Rijnhuizen 2005 – 2010: Organization and Finance
16:00 – 16:15	Panel discussion (closed)
16.15 – 17:00	Lab tour
17.00	Taxi to Grand Hotel Karel V
18.00 – 19.00	Internal discussion (closed session)
19.00 – 21.00	Working Diner in Grand Hotel Karel V

Friday, 30 September 2011

07.30 – 08.15	Taxi from Grand Hotel Karel V to Rijnhuizen
08.15 – 08:30	Welcome

STRATEGIC PLAN DIFFER AND FUTURE RESEARCH

	Also attending (until break): Prof. dr. ir. M.C.M. van de Sanden Prof. dr. A.J.H. Donné Dr. W. Koppers Prof. dr. F. Bijkerk Dr. A.F.G. van der Meer
08.30 – 08.45	Introduction by panel discussion leader: Prof. dr. Crabtree (closed)
08.45 – 09.00	DIFFER: new mission and organizational change of Rijnhuizen – Prof.dr.ir. M.C.M. van de Sanden
09.00 – 09:15	Discussion
09.15 – 09.45	Future Research at DIFFER – Prof. dr. ir. M.C.M. van de Sanden
09.45 – 10:00	Discussion
10:00 – 10:15	DIFFER: Organization, Governance and Finance – Dr. W.R. Koppers
10:15 – 10:30	Discussion
10:30 – 11:00	Panel discussion (closed)
11.00 – 11:15	Break
11:15 – 11:45	Meeting with chairman of the SAC-Rijnhuizen (*panel and Prof. dr. G. van der Steenhoven*)
11:45 – 12:30	Panel discussion
	As the need arises sooner or later:
12.30 – 13.00	Possible meeting with Rijnhuizen director, institute manager or other member of staff
13.00 – 14.00	Lunch with young scientists (PhD-students and postdocs)
14.00 – 17.45	Internal discussion (closed) – Tuinzaal

17.45 – 18.00	Presentation of main conclusions by Prof. dr. Parker to director FOM and director Rijnhuizen
18.00 – 19.00	Drinks – Parker presents conclusions to Rijnhuizen management team and senior staff
18.00 – 21.30	Dinner with Rijnhuizen management team, senior staff and director FOM
21.30	Taxi to Grand Hotel Karel V

6.3 List of programme leaders, staff members and PhD students interviewed

Programme presentations

The committee heard presentations and discussed with following persons:
- Richard van de Sanden – director Rijnhuizen / DIFFER
- Wim van Saarloos – FOM director
- Wim Koppers – Institute manager
- Lex van der Meer – division head GUTHz
- Britta Redlich – FELIX/FELICE
- Jos Oomens – Molecular Dynamics
- Fred Bijkerk – division nSI
- Andrei Yakshin – Physics of Thin Films and Multilayers
- Eric Louis – Advanced application of XUV Optics
- Juergen Rapp – division head PSI
- Pedro Zeijlmans van Emmichoven – Plasma Surface Interactions- Operations
- Gerard van Rooij – Low Temperature Plasma Physics and Heating
- Greg de Temmerman – Plasma Surface Interactions – Experimental
- Tony Donné – division head Fusion Physics
- Wim Goedheer – Computational Plasma Physics LT
- Peter de Vries – Plasma Diagnostics
- Marco de Baar – Tokamak Physics
- Egbert Westerhof – Computational Plasma Physics HT
- Gerard van der Steenhoven – Chairman of the SAC-Rijnhuizen

Lunch with junior scientists

On Friday 30 September, the committee had an informal lunch with the following junior scientists (in the absence of their advisors and Rijnhuizen management):
- Athina Kappatou (PhD-student in Fusion division)
- Wolf Weymiens (PhD-student in Fusion division)
- Menno Lauret (PhD-student in Fusion division)
- Igor Makhotkin (PhD-student in nSI division)
- Tione van de Boogard (PhD-student in nSI division)
- Steven Nyabero (PhD-student in nSI division)
- Gijs van Swaaij (PhD-student in PSI division)
- Rianne 't Hoen (PhD-student in PSI division)
- Josipa Grzetic (PhD-student in FELIX/FELICE division)
- Anouk Rijs (Postdoc in FELIX/FELICE division)

6.4 Extended description of the five point scale

(source: Standard Evaluation Protocol, Appendix 2)

5: Excellent

Research is world leading. Researchers are working at the forefront of their field internationally and their research has an important and substantial impact in the field.

4: Very good

Research is internationally competitive and makes a significant contribution to the field. Research is considered nationally leading.

3: Good

Work is competitive at the national level and makes a valuable contribution in the international field. Research is considered internationally visible.

2: Satisfactory

Work adds to our understanding and is solid, but not exciting. Research is nationally visible.

1: Unsatisfactory

Work is neither solid nor exciting, flawed in the scientific and or technical approach, repetitions of other work, etc.