Research Review

Chemical Engineering 3TU 2015

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1. The review committee and the review procedures

Scope of the assessment
The review committee Chemical Engineering 2015 has been asked to perform an assessment of research in chemical engineering conducted by Delft University of Technology Delft (TUD), Eindhoven University of Technology (TU/e) and the University of Twente (UT). The assessment includes four research units:

- two research units of the TUD; Chemical Engineering and Biotechnology;
- the Department of Chemical Engineering and Chemistry of the TU/e;
- the unit Chemical Engineering of the UT.

In accordance with the Standard Evaluation Protocol 2015-2021 for Research Assessments in the Netherlands, the committee's tasks were to assess the quality, the relevance to society and the viability of the scientific research at each of these research units as well as the unit's strategic targets and the extent to which the units are equipped to achieve these targets.

Composition of the committee
The composition of the committee was as follows:

- Prof. dr. Klaus Müllen (chair), director Max Planck Institute for Polymer Research, honorary professor at the universities of Mainz and Heidelberg, Germany;
- Prof. dr. Graham Hutchings, distinguished research professor Cardiff University and director of the Cardiff Catalysis Institute, United Kingdom;
- Prof. dr. Klavs F. Jensen, Warren K. Lewis Professor of Chemical Engineering, professor of Materials Science and Engineering. Massachusetts Institute of Technology, United States of America;
- Prof. dr. Guy B. Marin, professor in Chemical Reaction Engineering at Ghent University, Belgium;
- Prof. dr. John Pierce, lecturer Department of Biological Engineering Massachusetts Institute of Technology, United States of America;
- Prof. dr. Harm-Anton Klok, head of department Laboratoire des Polymères, Institut des Matériaux, Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland;
- Prof. dr. Paul Attfield, Professor of Materials Science at Extreme Conditions, University of Edinburgh, United Kingdom;
- Prof. dr. Rainer Haag, professor Institute for Chemistry and Biochemistry – Organic and Macromolecular Chemistry. Freie Universität Berlin, Germany.

Independence
All members of the committee signed a statement of independence to safeguard that they would assess the quality of the Chemical Engineering research of Delft University of Technology , Eindhoven University of Technology and the University of Twente in an unbiased and independent way. Any existing personal or professional relationships between committee members and the programme under review were reported and discussed in the committee meeting. The committee concluded that there were no unacceptable relations or dependencies and that there was no specific risk in terms of bias or undue influence.

Data provided to the committee
The committee has received the self-evaluation reports of the units under review, including all the information required by the Standard Evaluation Protocol (SEP), with appendices.

The committee also received the following documents:
- the Terms of Reference;
- the SEP 2015-2021;
- lists of publications;
- the previous Chemical Engineering Research Assessment Report.

Procedures followed by the committee
The committee proceeded according to the Standard Evaluation Protocol 2015-2021 (SEP). Prior to the first committee meeting, all committee members independently formulated a preliminary assessment of the unit under review. The final assessments are based on the documentation provided by the research units and the interviews with the management and representatives of the research units. The interviews took place on 14, 15, 16 September 2015 (see the schedule in Appendix 2) in Utrecht.

Preceding the interviews, the committee was briefed by QANU about research assessment according to SEP, and the committee discussed the preliminary assessments and decided upon a number of comments and questions. The committee also agreed upon procedural matters and aspects of the assessment.

After the interviews the committee discussed the assessments and comments. The – relevant parts of the – final version were presented to the research units concerned for factual corrections and comments. The comments were discussed in the committee. The final report was printed after formal acceptance.

The committee used the criteria and categories of the Standard Evaluation Protocol 2015-2021 (SEP). For more information see Appendix 2.

2. General Remarks

Chemical Engineering Research in the Netherlands
The assessment of Chemical Engineering Research in the Netherlands at three universities is performed by a committee, which bases its assessment on the self-evaluation reports of the involved universities and interviews with representatives during three days. The committee found the self-evaluation reports very informative and readable and had very pleasant and open interviews with all representatives. It enabled the committee to get a good impression of the organisation, strategy and quality of the Research Departments.

The committee is impressed by the quality of research in Chemical Engineering in the Netherlands. The research performed in the field of Chemical Engineering in the whole chain from molecule to product is in line with international levels and is highly competitive in the world. The institutes are successful in combining chemical engineering and chemistry, as well as chemical engineering and biology, which is in line with – and sometimes leading – the current developments in chemical engineering. In particular, the engineering side of the research can be highlighted in all three institutes.

The discipline has responded well to the previous review reports and has a positive attitude looking to the future. It is aligning itself with the needs of the Horizon 2020 objectives and opportunities. A strength is the linking with industry, and industrial staff often are embedded in the departments on a part time basis. One overall key strength has been the recruitment and retention of excellent young faculty who are winning ERC Starting and Consolidator grants (a key indicator of research quality).

The three institutes the committee reviewed are complementary in expertise and focus. There is obviously room for three Chemical Engineering Research Departments in the Netherlands. They all have their own profile and do not duplicate each other. The committee also noticed that the universities are investing in the infrastructure needed to enable the conditions required for the high quality research done in the institutes.

Although the institutes are organised in a different way, all are successful. The committee has spoken to people who were happy about their workplace. Overall the committee has a positive impression of the institutes .

Developments in the Dutch research context
The committee wants to comment on a few developments in the Dutch research context that raise some concerns. The self-assessment reports as well as the discussion with the representatives of the institutes point to a nationwide decline in direct or first stream funding. This development forces the researchers to put more effort into grant applications. This funding shift in itself can have its positive effects by stimulating quality through competitiveness. However the institutes all remarked on the limited accessibility of funds and varying funding opportunities. The individual NWO funding scheme VI provides a limited budget for the Veni and Vidi grants. Vici is only accessible for senior scientists. For the bigger grants and subsidies, young talents have to depend on full professors to get access. Furthermore, cooperation with industry is increasingly a condition for eligibility for the bigger grants. The committee has some concern that this condition will hamper opportunities to perform fundamental research. The institutes emphasized that the cooperation with industry in research projects also has a positive side and in many cases provides researchers with

enough space to do the fundamental research they want to do. Indeed, despite the general concern, there was much evidence to support this institutional view. The positioning of the main body of research between what is commonly thought of as pure academic research and industrial research has been very valuable to the Netherlands in particular and society in general, and can be rightly seen as one of the great values and distinguishing factors of the Dutch chemical engineering efforts. However, the committee advises the universities and institutes to keep an eye out for opportunities to access funds that will aid every researcher to keep a balance between societal relevance and applicability on the one hand and curiosity driven, basic research on the other.

The committee has seen that the decreasing direct funding has had a major effect on the workload of the academic staff. Researchers have had to put more effort into writing proposals for grant application. This, combined with an increase in teaching hours due to a recently increased student inflow in Sciences and Technology studies could form a risk for the quality of research.

Academic career system

The committee noticed that the academic career system in the Netherlands is changing, all three universities mentioned the introduction of a tenure track system. The details of this system vary per university, although it remains a hybrid system between a competitive individual career system as in the UK and USA and the more hierarchical system found in many European countries. The committee noted, however, two important problems that are common to all the evaluated departments. The first 'issue' is that the Dutch system does not allow any academic staff member other than a full professor to be the promotor of a PhD student. The promotion right, or *ius promovendi*, does not extend to assistant or associate professors. There is a discrepancy between this exclusive *ius promovendi* for full professors and the desire to attract talent on tenure track positions, including the desire that the tenure tracker should develop his or her own research line. The committee encourages the institutes to develop strategies to tackle this problem: such as by finding ways to by-pass the law, e.g. by appointing assistant and associate professors to personal professorships, or to lobby at the political level to change the law in this respect. The second key problem is that is not clear what the tenure track is aiming at. The committee understood from the interviews with junior faculty that the promotion criteria are not always clearly defined, and that tenure and promotion are two separate decisions which may not be well-synchronized. This could lead to unfortunate situations in which a non-promoted, but tenured individual could face very unclear career prospects. The committee suggests that the institutes survey their history to ascertain whether there is in fact a problem, and to assess their processes to help synchronize promotion/tenure to the extent possible and desirable. At university, tenure and promotion decisions must certainly share many common criteria, so clarifying their distinguishing features should be useful for both the tenure track faculty and the departmental administration.

The committee noticed that the young researchers were not visible in the information about the departments and their research on the respective websites. Indeed, some young and talented researchers have resorted to creating their own personal websites outside of the university websites to communicate their expertise and research interests. This invisibility is again contradictory to the policy that the tenure trackers should develop their own research lines. Facilitating proper exposure of the tenure trackers via departmental and university websites is an important – and easy – thing to do.

The committee also advises departments to consider clear career plans for the junior staff. Not all junior staff could refer to clear agreements on the path they should follow to achieve a full professorship. A clear career plan model could also involve a move to another university, as seems to be part of the policy of one of the universities, without being explicit about it.

PhD training

The committee was surprised by the average length of the PhD trajectory. The self evaluation reports mention that only a minority (6%, 15% and 45%) finishes within four years. Further explanation to the committee regarding the rituals and rules around the PhD defence explained part of the puzzle, but in the view of the committee it still seems necessary to reduce the average length. Measures are being taken to reduce the PhD duration and should be continued. The PhD completion was taken very seriously by most of the staff. It is positive that the institutes agree on implementing a go /no-go decision after the first year in the PhD trajectory. The committee encourages supervisors to agree on hard deadlines, such as the rule that the lab work should be completed six months before the end of the PhD contract, as well as the rule that the manuscript of the thesis should be ready at the end of the contract. Furthermore, the committee advises action to diminish the time between the finalisation of the thesis and the actual defence.

The recent start of graduate schools is a positive development. The graduate schools provide an opportunity to streamline the PhD trajectory and could be helpful in clarifying the admission rules. The PhD students were all quite satisfied with their working conditions and positive about their supervision and training. The committee appreciates the fact that all graduate schools trainings include scientific integrity education.

Governance and policies

With respect to gender balance it is noted that good young female faculty have been appointed but this has yet to move through to the senior staff. The skewed gender balance in Chemical Engineering research is an issue that is not restricted to the Netherlands, but the underrepresentation of female staff in the higher positions was striking and there still is a lot to be done. The committee noticed that the issue is on the agenda of the management of the institutes. They reported that they take measures to attract female talent, but the committee feels more needs to be done to really make a difference. The committee urges the boards of the universities and faculties to stay on top of this issue and to develop effective positive measures for the full range of academic positions, from PhD's to members of the board. Encouraging, coaching and convincing of the female students and staff members at each level is also needed. Equal opportunities for female scientists should be implemented on all levels in all institutes involved in this review.

The institutes have developed a policy and have taken measurements to stimulate awareness and knowledge of research integrity. The committee finds this positive and has seen that the PhD students were well informed about integrity issues and concepts. The committee could not yet measure whether this awareness is fully established. It advises to remain focused on the subject.

The committee also received information about the PDEng training programme, a two year technological designer training programme in cooperation with industry, and interviewed some PDEng students. This an interesting and attractive training programme, providing good opportunities for students to obtain a career in industry. However, the committee could not see the relation between this training programme and the research programmes.

3. Research review Chemical Engineering University of Twente

3.1. The research unit and its strategy

The research unit Chemical Engineering of the University of Twente is connected with three research institutes: MESA+ Institute for Nanotechnology, MIRA Institute for Bio-Medical Technology and Technical Medicine and the Program on Science Based Engineering. The research unit has two key domain orientations:

- Molecular & Materials Science & Technology (M&ME), which focuses on analysis and application of nano- and biomaterials;
- Science & Technology of Chemical Processes (C&PE), which studies the processes from nano to meter scale.

The two domains are the results of a reorganization aimed at strengthening the research unit ('Discipline'). In 2006 the focus of the research was narrowed down to research groups with a scientific profile in line with the three research institutes.

The research of the M&ME group addresses the following themes: Multi-functional supra-molecular chemistry; nanochemistry; nanomaterials and thin films; polymeric biomaterials and membrane based scaffolds; targeted nanomedicine; therapeutic strategies for tissue replacement.

The themes of the C&PE group are: heterogenous catalysis and photo-catalysis; membrane technology, process intensification; soft-matter, fluidics and interfacial phenomena, process scouting and design; chemical reaction engineering and separation technology.

The research unit describes the following components of its research strategy in the self-evaluation report:

- A balanced human resource management planning to strengthen the discipline.
- Flexible multi-disciplinary networks of research groups to structure the organization for challenge-driven research.
- MNCS (Mean normalised citation score) of 1.5 for all research groups.
- 25 PhD graduations per year.
- Attract and hold on to top academic talent.
- A substantial number of part-time professors from industry.
- Research priorities with regard to innovation and relevance to society.

This strategy is in line with the mission of the University of Twente, which states that 'research at the University of Twente centres on technology and the role of technology in society'.

The University of Twente provided the following information about resources:

Table 1 Research staff Chemical Engineering University of Twente 2008-2014 in fte (inc. =% increase from 2008-2014)

Research staff fte	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Inc.%**
Faculty staff	31.5	32.0	30.9	34.3	40.2	43.5	42.8	36%
Postdocs	33.8	34.7	41.1	35.8	40.2	42.9	45.0	33%
PhD students	109.9	110.4	106.9	111.6	135.6	141.7	145.0	32%
Total staff	175.2	177.1	178.9	181.8	216.0	228.1	232.7	33%

Table 2 Funding M&ME group and C&PE group in M€

M&ME funding in M€	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Inc.%**
Direct funding	6.2	6.6	6.5	6.9	7.8	7.9	7.8	26%
Research funds	1.0	1.4	1.9	2.2	2.5	2.4	2.2	110%
Contracts	2.1	2.3	2.0	2.0	3.9	3.4	3.8	81%
Total funding	9.3	10.3	10.4	11.1	14.2	13.7	13.8	48%

C&PE funding in M€	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Inc.%**
Direct funding	4.7	5.4	55.6	6.4	6.4	6.2	6.5	40%
Research funds	2.0	2.4	2.3	1.5	1.3	1.1	1.0	-53%
Contracts	1.9	2.5	2.5	3.6	3.3	3.6	4.3	124%
Total funding	8.6	10.3	10.4	11.5	11.1	10.8	11.8	37%

In the period under review the research unit had the following output:

Table 3 Aggregated results of the publications of the Research Unit University of Twente

	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**sum**	**av per year**
Refereed journal articles	194	208	214	233	259	292	279	1679	240
Books			1					1	
Book chapters	5	19	7	9	5	9	6	60	9
PhD theses UT	19	25	26	35	17	23	33	178	25
PhD theses external	1	1		1	2	1		6	1
Professional publications	1	1	5	3	1	1	2	14	2
patents	6	11	11	11	7	14	1	61	9

3.2. Qualitative and quantitative assessment

Research quality	**Relevance to society**	**Viability**
2	1	2

3.2.1. Research quality

Chemical Engineering at University of Twente benefits from the university's unique matrix structure, which enhances opportunities for interdisciplinary research and enables the faculty to address large research challenges. The close integration with science is essential for the unit to fulfil its mission "to develop and apply knowledge as well as to educate and inspire students at a top level, in two domains of expertise: (1) molecular & materials science for nano- and biomedical technology and (2) science & technology of chemical processes". This mission is consistent with current international developments in chemical engineering towards tighter integration with the sciences, specifically biology, chemistry and materials science. However, rather than dividing the mission in two domains, most programs aim to develop a continuum from science to engineering applications. Functionally, the University already appears to seamlessly integrate from synthesis and characterization to applications. The faculty has the advantage of engaging with two internationally recognized research institutes, MESA+ and MIRA, which provide excellent facilities for local, national, and international collaborations. The institutes provide junior researchers with opportunities they would otherwise not have. The new Science Based Engineering (PSBE) program in formation could be a vehicle for further building upon the close integration of science and engineering.

Strong internationally recognized research efforts in Molecular and Materials Science & Technology combine synthesis and characterization to gain new scientific insights and realize novel functional materials for biological and physical applications. Examples include bio-inspired multifunctional (macro)-molecular and supramolecular chemistry, self-assembly and polymer synthesis for medical applications, molecular understanding of interfacial tension and related transport, therapeutic strategies for regenerative medicine, and nanostructured materials and thin films, in particular oxides, for electronic, optical, and energy conversion devices. Complementary programs in Science & Technology of Chemical Processes produce internationally recognized advances in heterogeneous catalysis, photocatalytic conversion, polymer and inorganic membranes, microfluidic systems, reaction engineering, and separation technologies. The university has managed to sustain traditionally strong research areas, e.g., supramolecular chemistry, nanostructures, and catalysis, while starting new successful programs such as biomolecular nanotechnology. As a result, research has remained strong, at the leading edge, and internationally competitive.

The Discipline has 13 research groups each with a full professor as leader, and usually with at least one further Associate/Assistant/Adjunct professor. Groups range in size from 1 to 10 academic staff, with 3 as a typical size. Groups have distinctive titles and identities although there is a good level of complementarity between them. All of the groups have been productive with an average of 6.5 papers per academic per year per research fte over the review period. The groups publish in the expected refereed journals for their respective subfields. A CWTS analysis of the results of the Dicipline is included in the selfevaluation report. Collectively, they have a good average normalized number of cited publications (MNCS) of 1.48, and 1.6 times as many top 10% publications as expected. The high reputation of the unit's members is evidenced by a good number of Dutch personal grants, academic awards, and other forms of recognition. Younger staff have had strong success in obtaining ERC awards (4 Starting and 1 Consolidator), although the absence of Advanced grants is notable. Staff serve on several editorial boards and have organised 4 medium to large conferences. Much research is collaborative, and levels of participation in TTI/TKI networks are good.

The rate of publications has increased steadily with the number of staff during the evaluation period, but decreased in 2014 even though the number of postdocs continued to increase.

This development could possibly be connected to the high work stress felt by the staff combined with the increasing difficulties in securing funding, especially for more fundamental studies. Much of the research funding has shifted to contracts that could have fewer opportunities for high impact publications.

On the basis of the interviews and documentation the committee got a consistent picture of a very good unit, with good research funding and very good research. The representatives all reported about a good spirit, open doors and interdisciplinary collaboration. The committee, therefore, got a very positive impression of the groups and the environment.

3.2.2. Relevance to society

As a university, the training of young people is a primary benefit to society, and in an applied subject like Chemical Engineering the provision of the next generation of scientists and engineers is an important function. The unit has a high success rate in this area, with 67% of Masters graduates going to industry and 33% continuing to a PhD and an eventual research position in almost all cases. 190 PhDs graduated during the review period (equivalent to almost one per staff member per year). This represents a good training output. The unit has worked hard to attract students, with approximately equal numbers coming from the Netherlands, rest-of-EU, and rest-of-the-world (mainly Asia). Offering BSc and MSc courses in English helps this activity.

The university has a large number of industry contracts and five part-time full professors from industry participate in the Discipline. Moreover, it participates actively in initiatives from the Ministry of Economic affairs to strengthen the innovation potential and competitive position of Dutch industry, specifically Technological Top Institutes and Topconsortia for Knowledge and Innovation. Entrepreneurship and collaboration with industry are in the mission of the University and its institutes. The Discipline has an excellent record of spin-off companies, with 1-2 per year during the review period. All groups except one have generated at least one patent, with an impressive total of 61 over 7 years. 5 staff members have received valorization awards, and the Discipline has attracted 5 part time professors from industry. Cooperations with many large companies and SMEs are mentioned, although the amount or proportion of industrial funding of the unit is not clear. Entrepreneurial researchers are encouraged to commercialize research results and regional facilities help companies grow.

Outreach to the local community has been funded through the SNS program. This has been used to support the LLLab where school students and also teachers can experience high quality experimental research. 40 classes are run annually, which represents an impressive amount of science promotion. It would be interesting to know whether this has led to increased applications for scientific undergraduate courses at University of Twente and nearby institutes. Several staff members have spoken at festivals or in TV debates, broadening the outreach activities.

The committee has concluded that the unit makes an outstanding contribution to society.

3.2.3. Viability

Maintaining a productive matrix organization requires strong leadership and a highly collaborative environment. The research unit Chemical Engineering of the University of Twente has both. It has successfully demonstrated the ability to shape existing research efforts and to create new programs to address challenges in health, energy and sustainability. It has a well-articulated strategy for the discipline and the relevant institutes. The goals are realistic and challenging. The SWOT analysis accurately reflects the current situation. The

University is well placed to take advantage of its strength in organization and scientific staff in pursuing the identified opportunities. Scientific staff being stressed as well as research funding decreasing and shifting focus are unfortunately all too common challenges for leading research universities across the world. Nevertheless, the concerns will need to be addressed to maintain the high level of research productivity.

The management team has been effective in growing the Discipline over the review period, mainly through the initiation of 4 new groups with changes to some other groups. Numbers of staff, students, publications and grants have all increased which points to a positive trajectory for the unit. The commitment to data integrity as part of UT's research integrity policy is exemplary. By investing in emergent areas of research such as nanotechnology and the interface of bio and physical sciences, the Discipline is in a strong position to meet societal challenges and provide teams with critical mass in key areas. The Discipline's strategy maps well onto, and indeed embodies, that of the university as expressed in the 2020 Vision document.

The university has made significant investments in upgrading facilities available to chemical engineering, which will help keep the unit competitive. The committee appreciates these efforts and investments to revive and reinforce the chemical and process engineering oriented efforts. Perceptions about the Twente area relative to the western part of the country highlighted in the SWOT analysis present difficulties in attracting and keeping top talent. In order to attract top talent, the university has introduced a tenure track system, but providing internationally competitive start-up packages is a challenge under the current funding. The system for progression from tenure to a full professorship requires attention, although this is a national issue.

Progress has been made towards increasing the number of women among the scientific staff,but four recent hires have left for attractive offers or personal reasons. With roughly 30% women PhD students, greater representation of women is needed and the university has indeed that as a strategy. Graduate School courses that encourage female PhD students to continue and introduce them to role models and mentors may be helpful.

3.3. PhD programmes

The Discipline counts about 150 PhD students in 13 research groups. Each PhD student has a faculty staff member as his or her daily supervisor. Recently the university established the Twente Graduate School. All PhD students participate in the graduate school and are stimulated to participate in programmes of the associated national research schools.

PhD's take relatively long to finish their thesis programme. Only 70% of the students finish within 5 years and somewhat lower proportions in some research groups. Good planning and timely ending of PhD projects might make the unit more attractive to prospective students. It is positive that there now is a policy in place to diminish the time and strive for 90% of graduates completing within five years. The committee would encourage the unit to go even further than that towards a true 4 year PhD program. The new graduate school can help with this effort. The graduate school could possibly streamline the PhD trajectories and monitor the progress of the students. The students had a positive opinion of the graduate school and liked the online system for monitoring progress towards their PhD degree. However, they were concerned that not enough places are available for popular courses.

3.4. Research integrity policy

The unit has a research integrity policy in place that seems quite adequate to the committee. The Netherlands Code of Conduct for Scientific Practice is applicable to all employees and is leading for all the research activities in the Discipline. The university has a Scientific Integrity Complains Procedure which provides a system for reporting and dealing with possible violations of sceintific integrity. Students are well trained in the subject. As described in the self-assessment report an integrity culture is visible in the unit.

4. Research review Biotechnology Delft University of Technology

4.1. The research unit and its strategy

The Faculty of Applied Sciences of Delft University of Technology (TUD) consists of six departments. Two of these departments are evaluated in this research assessment: the Department of Biotechnology and the Department of Chemical Engineering. This chapter covers the review of the Department of Biotechnology.

The Department of Biotechnology covers the research area on all organization levels from gene to ecosystem. It selects, designs and tests new biobased catalysts, micro-organisms, and processes. It is the ambition of the department to integrate fundamental science, engineering and design, as well as ethical and societal research, directed to biotechnological process innovations. It aims to contribute to an international bio-based economy.

The Department is centred around six research themes: Cell System Engineering, Industrial Microbiology, Biocatalysis, Biotechnology and Society, Bioprocess Engineering and Environmental Biotechnology. The department formulated a ten year strategy focused on industrial and environmental biotechnology. It is the objective to develop innovative biological processes for industrial production and for environmental treatment methods by integrating the fundamental principles of thermodynamic, kinetics, microbial physiology and transport with process design and scale-up.

The department invests strongly in relations with industry and public bodies. The self-evaluation report describes the following targets:

- Profiling as a knowledge base for biobased processes
- Attract and keep top scientific staff
- Exploiting the potential of the Environmental Biotechnology research theme
- Obtain more personal grants from NWO and ERC
- Strategic investments in infrastructure

The department provided the following information about resources

Table 4 Research Staff Department Biotechnology TUD

Research staff fte	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Inc.%**
Faculty staff	31.9	35.1	32.9	33.5	32.0	31.6	30.0	-5,9%
Postdocs	20.2	16.2	21.0	22.3	20.3	21.2	19.4	-4.0%
PhD students	63.9	66.2	70.6	67.4	69.0	74.9	77.4	21,1%
PDEng	15.3	24.3	31.4	31.0	28.0	26.2	25.6	67.3%
Total staff	131.3	141.8	155.9	154.2	149.4	153.8	152.4	16.0%

Table 5 Funding Department Biotechnology TUD

Biotechnology funding in M€	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Inc.%**
Direct funding	7.4	5.3	5.6	7.1	5.8	6.8	6.1	-17.5%
Research funds	1.9	2.6	4.2	3.2	5.6	4.2	5.6	194%
Contracts	6.2	5.7	4.8	4.0	6.0	4.5	6.5	4.8%
Total funding	15.5	13.6	14.6	14.2	17.4	15.5	18.2	17.4%

In the period under review the research unit had the following output:

Table 6 Aggregated results of the publications of the Department Biotechnology TUD

	2008	2009	2010	2011	2012	2013	2014	sum	av per year
Refereed articles	160	161	149	159	151	136	168	1084	155
Book chapters	12	15	17	13	19	15	24	115	16
PhD theses	15	14	19	8	8	10	17	91	13
PDEng design projects	9	7	13	10	13	11	14	77	11
Conference papers	31	37	21	29	17	21	5	161	23
Total	227	234	219	219	208	193	228	1528	218

4.2. Qualitative and quantitative assessment

Research quality	Relevance to society	Viability
2	1	2

4.2.1. Research quality

The department of Biotechnology at Delft University of Technology has a very good international reputation and visibility. Its mission to establish an "international bio-based economy" is highly relevant for society. The new organizational structure with six research themes and disciplinary origins allows for high multidisciplinary and internal cooperation. It has a clear and open management structure which operates well and is well-received by departmental staff.

Biotechnology at TU Delft is highly respected around the world. The department has an enviable publication output, very good engagement with industry, and great success in attracting major governmental and industrial funding grants. In the overall area of biotechnology associated with microbial fermentation and process engineering, the department is world class and the combined efforts of the multiple groups within the department have produced a large number of papers and a large number of initiatives. The examples of the Kluyver Center and BE-BASIC are just two very large examples of excellence in these areas. The department plays its part very well in keeping the Netherlands at the forefront of biotechnology in the world.

High impact papers in excellent journals are produced together with significant patent applications – indicative of the broad range of research, from basic to quite applied, that takes place in the department. The self-evaluation reports presents a MNCS of 1.34. During the reporting period the department published 89 articles in top 10% journals. The department's unique strength appears to be in its translational role of bringing new research results and findings to a level where industry can evaluate and further develop them for further use. This is a completely non-trivial capability, and is difficult to balance with academic research and pursuits. The department does this very well and the committee would encourage the department to continue to develop these strengths.

Over the last reporting period the department faced the challenge of an increasing student number with a constant staff number. The staff managed very well so far but this has to be adapted when further expansion (i.e. with international students) is planned. The scientific output (papers and patents) is very good both in quality and quantity and some excellent collaborations have been established.

While the staff situation is very good, the strength of the department originates from a few excellent PIs. Furthermore, many young staff members are waiting for promotion and a clear perspective should be provided. A more general issue is the right for assistant/associate professors to supervise PhD students independently from full professors. Here a full transition to the PI-system is encouraged.

The funding situation is excellent although the direct funding was reduced while the 2nd/3rd funding lines improved especially in the sector of research grants. Here several outstanding prizes i.e. the Spinoza Award, a VICI award and two ERC consolidator grants should be mentioned.

4.2.2. Relevance to society

TU Delft Biotech has done a very good job in creating societal benefits – most notably through its excellent record of graduate training, external courses, but especially by its strong engagement with industry and incorporation of graduates and innovative ideas derived from the department that have commercial impact. Individuals are well-represented on various governmental, representative, and technical boards and societies and contribute in that manner also.

The group has been a catalyst for the leveraging of large scale government grants with private money, and the outputs developed by the Kluyver Centre and BE-BASIC are respected worldwide. Combined with the very capital efficient establishment of the Bioprocess Pilot Facility BV, the group is well-positioned to continue its enviable progress in both basic and applied aspects of fermentation and process development.

The augmentation of a group – Biotechnology and Society – focused on responsible innovation and outreach has amplified both direct outreach efforts as well as membership in worldwide councils and committees focused on responsible use of biotechnology. As such, the department plays a very useful and visible role in the evolution of policy and societal perspectives regarding biotechnological developments.

Besides many ecologically relevant processes (including waste water treatment) the department has an excellent record of translating research results into technology that is implemented by several companies or official partners..

4.2.3. Viability

The department as such is very well set up for the future. The unit does remarkably well in its chosen areas, even though it is not an overly large department. There has been active management of the structure of the department over the past period; development of many significant research programs and consortia; and the department has rectified some long-standing infrastructure problems by successfully providing for essential new laboratory space. The current management of the group is well-supported by the previous managerial experiences of group members, and in general there appears to be a collegial and rational approach to dealing with issues – not least the ever changing funding outlook.

The structural decision of the TU Delft to assemble several departments in a new research building as well as to initiate a bioinstitute across the university campus are excellent measures to strengthen this field. This initiative needs full support, it offers unique possibilities for intensifying cross-departmental collaboration. The committee encourages the department to initiate strong, ad hoc incentives to ensure this cross-departmental collaboration occurs.

The department has done a very good SWOT analysis and the committee encourages the department to continue with executing on some of the issues brought up in the analysis so that it can retain its strong position in the biotechnology landscape. The committee agrees with the statement that integration and translation with industrial projects is an almost unique, very strong aspect of the department. The aspirations to compare with INSA and MIT are laudable and realistic.

However, an increase of direct funding and an investment budget will be required. Two high profile faculty need to be replaced due to retirement and excellent international recruitments with an additional budget should be realized. Also, it would be advisable to increase the number of female staff numbers in this context. Biotechnology is like all engineering sciences hampered by a non-equal distribution of female staff. The department is already in the vanguard in the Delft context and is encouraged to strenghten this position. For a sustainable and competitive future of the department several strategic investments are required where the university should make significant contributions. The viability of the department has great opportunities.

4.3. PhD programme and 4.4. Research integrity policy

The Departments of Biotechnology and Chemical Engineering of Delft University of Technology have a common policy regarding PhD supervision and research integrity policy. For the assessment of these subjects see section 5.3. and 5.4.

5. Research review Chemical Engineering Delft University of Technology

5.1. The research unit and its strategy

The Faculty of Applied Sciences of Delft University of Technology (TUD) consists of six departments. Two of these departments are evaluated in this research assessment: the Department of Biotechnology and the Department of Chemical Engineering. This chapter covers the review of the Department of Chemical Engineering.

The discipline of the research unit is the art-turned-science of converting molecular understanding into products and processes that benefit mankind, using a healthy dose of chemistry, mathematics, physics, biology and material science whenever it is called for.

It is the mission of the research unit to successfully apply its science to meet the societal needs for new products and processes. The department is divided into seven sections headed by a section chair: Advanced Soft Matter, Catalysis Engineering, Materials for Energy Conversion and Storage, Opto-Electronic Materials, Organic Materials & Interfaces, Product and Process Engineering, Transport Phenomena.

The department sees the health and energy areas as the biggest challenges and opportunities: medical topics that are easily recast into transport problems with a molecular twist, devices for energy conversion that have supramolecular or nanoscale complexity that is not easy to produce at any scale.

The self-evaluation report describes the following targets:

- Stimulate multidisciplinarity by strengthening bottom-up scientific collaborations
- Strengthening the theme of storage and conversion of energy
- Integrate the expertise of transport phenomena and fluid mechanisms
- Attract excellent faculty members with a focus on junior positions
- Growth in winning more senior personal grants
- Profits from contract research are used for infrastructure investments

The department provided the following information about resources:

Table 7 Research Staff Department Chemical Engineering TUD

Research staff fte	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Inc.%**
Faculty staff	31.5	30.0	30.0	28.3	30.7	35.8	33.7	7%
Postdocs	20.6	17.1	16.7	17.7	18.2	17.4	16.4	-20%
PhD students	63.7	69.3	79.6	83.8	85.9	84.1	79.1	24%
PDEng	15.7	23.4	22.1	17.7	17.1	19.3	29.2	86%
Total staff	131.4	139.8	148.3	147.5	151.9	156.6	158.4	20,5%

Table 8 Funding Department Chemical Engineering TUD

Chem Eng funding in M€	2008	2009	2010	2011	2012	2013	2014	Inc.%
Direct funding	9.8	8.6	7.1	7.1	8.0	5.6	6.4	-34.7%
Research funds	1.3	1.8	2.2	2.1	1.9	1.9	1.9	46%
Contracts	4.3	5.0	5.6	6.5	5.9	5.2	6.5	51%
Total funding	15.4	15.4	14.9	15.6	15.7	12.6	14.4	-6.4%

In the period under review the research unit had the following output:

Table 9 Aggregated results of the publications of the Department Chemical Engineering TUD

	2008	2009	2010	2011	2012	2013	2014	sum	av per year
Refereed articles	180	159	147	142	145	170	168	1111	159
Book chapters	13	15	11	9	7	4	11	69	10
PhD theses	10	12	16	8	19	15	12	92	13
PDEng design projects	7	7	9	11	8	10	6	59	8
Conference papers	33	32	33	21	28	21	13	181	26
Total	251	230	219	190	210	220	215	1512	216

5.2. Qualitative and quantitative assessment

Research quality	Relevance to society	Viability
2	1	2

5.2.1. Research quality

Chemical Engineering in TU Delft demonstrates a number of strengths and contributes strongly to the overall discipline. The department has responded well to the previous review reports and has a positive attitude looking to the future. In particular it is aligning itself well with the needs of the Horizon 2020 objectives and opportunities.

The Delft Chemical Engineering Department conducts very good, internationally recognised research. This is evidenced by a substantial number of papers in top peer reviewed journals. There are clear examples of research of the highest quality that is internationally leading in terms of rigour and reach. There are also clear examples of impact of the research on society as a whole especially through start-up companies and patent licences. The high appreciation of the department by the peers is also reflected in the significant number of awards and prizes that have been bestowed on various members of the department.

The programme is making strong contributions to the international field, merging scientific and engineering issues. The committee encourages the department to go on in that direction. The quality of the research that is performed at the department is recognised on an international level. The research that is performed successfully tackles fundamental problems but also makes contributions that have a direct impact on and help e.g. industry. The department has a very good international reputation. The junior faculty are winning ERC starter and consolidator grants, but at present there is no evidence of ERC Advanced grants.

5.2.2. Relevance to society

The committee recognises the department's contributions to society as outstanding. This is underlined, amongst others, by various patents and licences and by a significant amount of contract research and joint research projects with industry. Indeed, the department's interaction with industry leads to high impact research as it tackles key problems from a fundamental level. The department is succesful in identifying societal needs for new products and processes and in applying research results to meet those needs. The department combines design, synthesis, and characterization studies with the development of processes, production tools and application. It has a strong a strong engagement with industry and with University Medical Centres in Rotterdam and Leiden. The department is rooted in the industrial landscape. The selfevaluation report presents many examples of partnerships with industry that lead to publications.

5.2.3. Viability

The department provided a transparent SWOT analysis in the selfevaluation report, which point at a clear strategy for the future. The committee encourages the department in the chosen path integrating chemistry with engineering to formulate functional materials for growing application areas. The research directions and strategy are well-defined and in line with the expertise of the faculty. Over the past years, the department has also been very active and successful in appointing a number of promising young scientists on tenure track positions. In the self-assessment report, it is repeatedly stated that the department is abandoning the traditional research group based organization towards a department PI-centred structure. The presentation of the research activities in the report, and in particular the presentation of the department on the internet, indicate that this process is still in progress.

5.3. PhD programmes

The numbers of PhD students of the Departments of Biotechnology and Chemical Engineering Delft increased during the review period with 21% and 24% to 77.4 and 79.1 fte. The PhD trajectories of the Biotechnology and Chemical Engineering Departments Delft take, according to the data presented in the self-assessment report, far too long. Only a few finish their PhD in time (respectively 5.6% and 6.3%) The committee learned that part of the delay is due to the period between the official defense of the thesis and the moment the manuscript is delivered by the student. Another reason for delay is the fact that PhD students are sought after in industry and get a job before they finish writing. The management explained to the committee that it used to be the norm at TU Delft to take a one or two year extension for the PhD trajectory. It takes some time to change this attitude. It is now decided that contracts of PhD students are not extended anymore.

The graduate school of TU Delft is founded in 2012. One of targets of this school is to reduce the PhD finishing time to below 5 years, preferably 4,5 years. The aim is to have the draft version of the thesis ready at the end of contract (i.e. 4 years). Another measurement that should reduce the length of the PhD trajectory is the introduction of the go/ no-go decision after one year.

The graduate school is valued as very positive by the committee. It was also very much appreciated by the students, who commented on the very useful courses and it also seems an instrument that can be used to "streamline" the PhD process and help in reducing the average graduation time down to a more reasonable level (4 – 4.5 years). The committee however did not yet see the results of these measurements and encourages the department to remain alert on this issue.

5.4. Research integrity policy

The self- evaluation report contains a clear research integrity plan. The TUDelft has put a structure in place for dealing with problems in the area of research integrity as well as training modules for PhD students. In the daily practice research integrity is a frequent topic of informal discussion. The committee was able to check the implementation of the plan in scientific practice, which indicated that there is sufficient awareness among the researchers.

PhD students reported that scientific integrity is part of the first course offered by the graduate school. The PhD students are well aware of the issues that belong to this subject. They also report that these issues are discussed in the research groups.

6. Research review Chemical Engineering and Chemistry Eindhoven University of Technology

6.1. The research unit and its strategy

The Department of Chemical Engineering and Chemistry is one of the nine departments of Eindhoven University of Technology (TU/e). The self-assessment report describes that the research groups in the department are arranged in two thematic clusters:

- Molecular Systems and Materials Chemistry, which focuses on the design and synthesis of novel molecules, macromolecules, supramolecular assemblies and functional materials. Researchers in this cluster investigate the relation between the structure of advanced materials and their functional performance
- Chemical and Process Technology, which covers a broad spectrum of research in the areas of reactor and separation technology, process intensification and catalysis. The primary topics of investigation include multi-scale multi-phase flow, transpot phenomena, integrated and intensified reactors, catalysis, new separations and affinity solvents, and renewable feedstock conversion.

In the past seven years some major changes have taken place. There has been a reorientation and reorganization of the department resulting in among others major investments for chairs in Catalysis and Process Engineering, new chairs in Materials Chemistry and Physical Chemistry, appointments of junior staff members and participation in the Institute for Complex Molecular Systems.

The self-assessment report describes the following target for the near future:

- to establish two new chairs: Polymer Materials and Technology and Inorganic Chemistry;
- participation in Gravitation Programmes Functional Molecular Systems and Multiscale Catalytic Energy Conversion;
- participation in InSciTe: new tenure track scientific staff.

The department provided the following information about resources:

Table 10 Research Staff Department Chemical Engineering and Chemistry TU/e

Research staff fte	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Inc.%**
Scientific staff	48.5	47.0	47.4	48.4	46.8	41.1	39.2	-19%
Postdocs	50.1	51.1	57.4	49.1	44.2	32.2	37.5	-25%
PhD students	157.6	173.8	183.3	214.0	203.9	186.8	180.3	14%
Total staff	256.2	271.9	288.1	311.5	294.9	260.1	257.0	0,3%

Table 11 Funding Department Chemical Engineering and Chemistry TU/e

Chem Eng funding in M€	2008	2009	2010	2011	2012	2013	2014	Inc.%
Direct funding	16.1	14.2	14.6	15.0	14.3	13.1	13.0	-19%
Research funds	4.2	4.3	3.8	4.2	3.7	3.6	2.6	-38%
Contracts	10.2	12.1	14.3	13.5	11.7	11.3	11.3	11%
Total funding	30.5	30.6	32.7	32.7	29.7	28.0	26.9	-12%

In the period under review the research unit had the following output:

Table 12 Aggregated results of the publications of the Dept. Chemical Engineering and Chemistry TU/e

	2008	2009	2010	2011	2012	2013	2014	sum	av per year
Refereed articles	319	371	304	283	333	339	286	2235	319
PhD theses	32	43	32	32	43	41	39	262	37
Conference papers	99	120	159	67	71	62	47	625	89
Patents	14	11	8	3	4	8	3	51	7
Total	464	545	502	384	451	450	375	3173	453

6.2. Qualitative and quantitative assessment

Research quality	Relevance to society	Viability
1	1	2

6.2.1. Research quality

The research performed at the department is strongly focused on macromolecular chemistry on one hand and chemical process engineering on the other hand. Both clusters contribute to the scientific strength and world class quality of the department. The performed research is internationally recognized as excellent with several outstanding groups in the field of macromolecular chemistry. The unit has been shown to be one of the few most influential research groups in the world in Chemical Engineering. The committee is impressed by the emerging modelling activities.

An exceptionally high number (six) of Advanced Grants of the European Research Council as well as one Consolidator and two Starter Grants have been obtained. The department won the highest award of the Dutch Research Council (NWO), the Spinoza award, and was also very successful in receiving funding from national funding, in particular two Gravitation Programmes. The theme of each of the latter corresponds moreover very well with the targets selected by the department: Functional Molecular Systems and Netherlands Center for Multiscale Catalytic Energy Conversion, the former being coordinated by a group leader of the department. The "crown indicator" (MNCT) of the Centre for Science and Technology Studies (CWTS) is well above the world average: 1.93. The number of very highly, i.e. top 1% of articles in the discipline, cited papers has been around 10 for every year of the reporting period and testifies of the scientific relevance of the performed research. The committee is convinced that a policy encouraging interaction between the clusters would harness the available potential for synergy.

The committee is impressed by the activity of the department in attracting high quality junior professors with an international background and with a reasonable gender balance. The intense collaboration with chemical industry is convincingly supported. The department expressively states that it is "satisfied with the present balance between fundamental sciences and societal or technologically motivated research." In view of the increasing financial pressure the committee is of the opinion that this remains a challenge in particular for the junior faculty.

6.2.2. Relevance to society

The relevance to society of the research performed by the department and in particular by the Chemical and Process Technology cluster is most clearly indicated by the very strong interaction with the industrial world. There are very strong and long lasting bilateral collaborations with multinational companies, both from the Netherlands (DSM, Philips, Shell, AkzoNobel, Unilever) and abroad (SABIC, BASF, Dow Chemical) next to good relations with SME's. The former are also very productive: more than 18% of the scientific publications over the reporting period are co-publications with industry. Part-time professors from industry play an important role in this. The list of spin-off and start-ups is impressive both in terms of numbers as of their ongoing relation with the department. The department has also been very effective in contributing to Dutch public-private partnership (PPP) programs and other initiatives such as the Institute for Science and Technology (InSciTe). The scientific staff has been co-initiator or coordinator of several FP7/H2020 projects. Numerous prizes and valorisation grants have been awarded to staff members or spin-off companies of the department. Several members of the scientific staff have been involved in popularization activities making use of, among other things, social media. The department is recognised for making an outstanding contribution to society.

6.2.3. Viability

The merging of the four existing focal areas, i.e. supramolecular chemistry, polymer chemistry and technology, process engineering and catalysis into two clusters: Molecular Systems and Materials Chemistry and Chemical and Process Technology can be considered a wise choice. It can even be looked at as a specification of the two terms in the denomination of the Department of Chemical Engineering and Chemistry. This duality actually constitutes one of the strengths and the resilience of the department. The two clusters are balanced in size and complement each other both in terms of strong points, scientifically outstanding chemistry groups and groups excelling in valorisation of research results in the chemical and process technology cluster, and in terms of possible cross fertilization. The department has managed to maintain a short-term plan to fill the chairs in polymer and inorganic materials despite the first money stream constraints. The department is very well equipped for the future.

The major threat for the future lies in the decrease of the direct funding of the department. The latter has decreased by a significant fraction over the reporting period. Next to a general decrease of direct government funding, this was due to a change in the TU/e internal distribution scheme of the first money stream. The newly introduced scheme gives more weight to the number of bachelor's/master's students. Despite the excellent score of the chemical engineering study programmes (best qualification awarded in the Netherlands) the number of students enrolling remains limited compared to other programs at TU/e. If this trend cannot be reversed there is a risk of growing unbalance between direct funding and contract funding, or worse, a risk of entering in a scenario where new cuts in the scientific staff will be required.

6.3. PhD programmes

The management of the department described that PhD supervision includes a plan for coaching and supervision, that has to be agreed upon in the first year. After the first year it is decided whether the PhD student can continue the project (a go/ no-go decision). The Human Resources department monitors the regular supervision. The selfevaluation report shows that 15% of the PhD students finishes within four years and 56% within five years. The aim of the department is to reduce completion time as far as possible. The representatives emphasized during the interviews with the committee that the culture in the unit is that a PhD trajectory should be as short as possible. The target for every PhD student is to deliver the manuscript before the end of contract (i.e. four years).

The scientific part of the training is organized at the Dutch level through research schools. Personal and professional development, e.g. skills courses in intellectual property, writing articles and abstracts, presenting, career orientation, is organized at the TU/e level by the TU/e graduate school via the PROOF program. Each PhD student has an individual Training and Research Guidance Plan from the beginning of her/his project on. The graduate school in Eindhoven is only recently funded and not many PhD students already have experiences with this school. The committee is of the opinion that the graduate school provides opportunity to streamline the PhD project and could be helpful in clarifying the admission rules.

The timely PhD completion was taken very much serious by the staff, however, the data presented to the committee do not yet show the results of the good intentions of the department to shorten the PhD trajectory. The committee encourages the department to continue on the path taken towards reducing the PhD completion time. The PhD students themselves were content with their supervision and facilities.

6.4. Research integrity policy

The university established a specific TU/e Code of Conduct. This code includes research-oriented and design-oriented practices at TU/e and emphasizes the societal responsibility that comes with working, directly or indirectly, on the development of technologies. The TU/e Code of Conduct is organized around five central values (trustworthiness, intellectual honesty, openness, independence, and societal responsibility) that jointly characterize good scientific conduct. These values translate to certain behavioral norms and principles. Compliance with the general principles of professional scientific conduct is required by contract. Serious infringements can result in termination of employment at TU/e.

PhD students have to attend a workshop on Scientific Integrity organized within the PROOF program. At the end of their research project PhD students are required to sign a declaration that their thesis was written in compliance with the TU/e Code of Conduct.

7. Recommendations

The committee was impressed by the overall high standard of research quality in Chemical Engineering in the Netherlands. In the view of the committee, however, maintaining the optimal balance between societal relevance and applicability on the one side and space for curiosity driven, basis research on the other side, is necessary to preserve this high standard. The committee is concerned about the accessibility of national research funds. The funds should be accessible for every researcher. Age and hierarchical position in the university should not be conditions for eligibility.

A risk for the quality of research is the increasing work load of the scientific staff, due to the growing student numbers and the amount of time investment in writing grant proposals. The committee advises the boards of the universities to have an open eye for this work load and e.g. to create teaching free periods for young scientists in which they can work on their proposals and build on their research line and track record.

The committee encourages the institutes to develop strategies to tackle the problem that assistant and associate professors do not have the *ius promovendi*: on the one hand to find legitimate ways to by-pass the law, e.g. by appointing them to personal professor, and on the other hand by lobbying on the political level to change the law in this respect.

The committee also advises departments to consider clear career plans for the junior staff. A tenure track agreement should not only lead to a tenure position but should also contain clear criteria and time schedules for promotion.

The average length of PhD trajectories should be reduced. The committee encourages the implementation of graduate schools and sees a positive development in the introduction of hard deadlines, like the go/no-go decision after one year, the rule that the lab work should be done six months before the end of the contract, as well as the rule that the manuscript of the thesis should be ready at the end of the contract. And furthermore the committee advises action to reduce the time between the finalisation of the thesis and the actual defense.

The institutes are aware of the fact that it is necessary to improve the gender balance in the higher scientific positions. The committee encourages the institutes to develop positive measures in this respect. Besides improving recruitment and selection procedures, it needs encouraging, coaching and convincing of the female students. This stimulating policy should at least start at the PhD level.

Appendices

Appendix 1: Curricula vitae of the committee members

Prof. Dr. K (Klaus) Müllen
Klaus Müllen joined the Max Planck Society in 1989 as one of the directors of the Max Planck Institute for Polymer Research. His PhD degree was granted by the University of Basel in 1972. He received his habilitation in 1977 at ETH, Zürich. In 1979 he became a Professor at the University of Cologne, and in 1983 at the Johannes-Gutenberg-University, Mainz.

In 1993 he was awarded the Max Planck Forschungspreis, in 1997 the Philip Morris Forschungspreis, in 2001 the Nozoe-Award, in 2002 the Kyoto University Foundation Award, in 2003 the Science Award of the "Stifterverband", in 2006 the Belgian Polymer Award, in 2008 the Innovation Award, the Nikolaus August Otto Award and 2009 the Society of Polymer Science Japan International Award. Many more honors followed since then: 2011 ACS Award in Polymer Chemistry; Tsungming Tu Award, Taiwan; 2012 BASF-Award for Organic Electronics; 2013 Franco-German Award of the Sociéte Chimique de France; Adolf-von-Baeyer-Medal, GDCh; Utz-Helmut Felcht Award, SGL Group; ChinaNANO Award. In 2014 he obtained the Carl Friedrich Gauß-Medal of the "Braunschweigische Wissenschaftliche Gesellschaft" and he was winner of the ACS Nano Lectureship Award.

Klaus Müllen obtained honorary professorships from East China University of Science and Technology, Shanghai; the Institute of Applied Chemistry Chinese Academy of Sciences, Changchun; the Institute of Chemistry Chinese Academy of Science, Beijing; the Jiao Tong University, Shanghai, the University of Mainz and the University of Heidelberg. He received honorary doctorate degrees from the University of Sofia, the Karlsruhe Institute of Technology (KIT), the Jiatong University, Shanghai and the University of Ulm. In 1999 he became a member of the German Academy of Sciences "Leopoldina". From 2008-2009 he served as president of the German Chemical Society (GDCh). In 2010 he received an Advanced ERC Grant for his work on nanographenes. Since 2012 he is corresponding member of the North Rhine-Westphalian Academy of Sciences and Arts and 2013 he became a honorary member of the American Academy of Arts & Sciences. During 2013 and 2014 he was president of the German Association for the Advancement of Science and Medicine. 2015 he became a member of the European Academy of Sciences (EURASC) and corresponding member of the "Braunschweigische Wissenschaftliche Gesellschaft".

He is currently associate editor of the Journal of the American Chemical Society. His broad research interests range from the development of new polymer-forming reactions, including methods of organometallic chemistry, to the chemistry and physics of small molecules, graphenes, dendrimers and biosynthetic hybrids. His work further encompasses the formation of multi-dimensional polymers with complex shape-persistent architectures, nanocomposites, and molecular materials with liquid crystalline properties for electronic and optoelectronic devices. He owns about 60 patents, published nearly 1700 papers .

Prof. Dr. G (Graham) Hutchings

Education and Qualifications:
1972 - BSc in Chemistry with First Class Honours, University College London
1975 - PhD in Biological Chemistry, University College London. Supervisor: Prof C Vernon
2002 - DSc (University of London)

Professional Appointments:
1975 - 1984 ICI Petrochemicals Division
1975 - 1978 Technical Officer, Research Department Wilton, Teeside
1978 - 1981 Plant Manager and Production Support manager, Oil Works, Teeside
1981 - 1983 Senior Research Officer, AECI, Modderfontein, S Africa (Seconded)
1983 - 1984 Chief Research Officer, AECI, Modderfontein, S Africa (Seconded)
1984 - 1987 University of Witwatersrand, S Africa
1984 - 1987 Lecturer (1984-6),Senior Lecturer (1986-7)in Chemistry
1987 - present Professor
1987 - 1997 University of Liverpool
1987 - 1994 Assistant Director of the Leverhulme Centre for Innovative Catalysis
1994 - 1997 Deputy Director and Professor
1997 - 2009 Cardiff University
1997 - 2006 Head of School and Professor of Physical Chemistry
2006 - present Distinguished Research Professor
2008 - present Director: Cardiff Catalysis Institute
2010 - 2012 Pro Vice-Chancellor Research

Research interest
- The study of gold nanocrystals as novel active heterogeneous catalysts and their characterisation.
- The design of selective oxidation and hydrogenation catalysts and their study using in situ spectroscopy.
- Designing novel heterogeneous catalysts

Some prizes/ Distinctions
- IChemE Environwise Award for Green Chemistry 2007.
- Winner Dow Methane Challenge 24th January 2008.
- Elected Fellow of the Royal Society 2009
- RSC Award for Surfaces and Interfaces 2009
- I Chem E Sustainability Award 2009
- Appointed chair of SCORE 2010-2013
- Elected member Academia Europaea September 2010
- France Great Britain Chemistry Prize 2011
- Dechema Alvin Mittasch Award 2012
- International Association of Catalysis Societies Heinz Heinemann Award 2012
- Thompson Reuters Citation Laureate September 2012
- Distinguished Visiting Lecturer, Catalysis Society of South Africa, 2013.
- Royal Society Davy Medal 2013
- Dewar Lectureship, Queen Mary College, London.
- Thompson Reuters Most Cited Scientist Award 2014

Prof. Dr. K (Klavs) Jensen
Warren K. Lewis Professor of Chemical Engineering, Professor of Materials Science and Engineering. Department of Chemical Engineering. Massachusetts Institute of Technology.

Education
Ph.D., University of Wisconsin, 1980
M.Sc., Technical University of Denmark, 1976

Honors and Awards
IUPAC-ThalesNano International Prize, 2012
AIChE's William H. Walker Award for Excellence in Contributions to Chemical Engineering Literature, 2011
Elected AIChE Fellow, 2009
American Academy of Arts & Sciences, 2008
Royal Society of Chemistry, 2004
National Academy of Engineering, 2002
R. H. Wilhem Award, American Institute of Chemical Engineers, 2000
Berkeley Lectures in Chemical Engineering, UC Berkeley, 2000
Charles M.A. Stine Award, AIChE, 1995
Allan P. Colburn Award of the AIChE, 1987
John Simon Guggenheim Fellowship, 1987
Camille and Henry Dreyfus Teacher-Scholar Award, 1987
Presidential Young Investigator Award (NSF), 1984
Young Author's Award of the Electrochemical Society, 1983

Prof. Dr. G. (Guy) Marin
Guy B. Marin is professor in Chemical Reaction Engineering at Ghent University (Belgium) and directs the Laboratory for Chemical Technology. He received his chemical engineering degree from Ghent University in 1976 where he also obtained his Ph.D. in 1980. He previously held a Fulbright fellowship at Stanford University and Catalytica Associates (USA) and was full professor from 1988 to 1997 at Eindhoven University of Technology (The Netherlands) where he taught reactor analysis and design. The investigation of chemical kinetics, aimed at the modeling and design of chemical processes and products all the way from molecule up to full scale, constitutes the core of his research . He wrote a book "Kinetics of Chemical Reactions : Decoding Complexity" with G. Yablonsky (Wiley-VCH, 2011) and co-authored more than 300 papers in international journals. He is editor-in-chief of "Advances in Chemical Engineering" , co-editor of the Chemical Engineering Journal and member of the editorial board of "Applied Catalysis A: General". In 2012 he received an Advanced Grant from the European Research Council (ERC) on "Multiscale Analysis and Design for Process Intensification and Innovation (MADPII)" . He was selected to deliver the 2012 Danckwerts Annual Award lecture. He chairs the Working Party on Chemical Reaction Engineering of the European Federation of Chemical Engineering and is "Master" of the 111 project of the Chinese Government for oversees collaborations in this field.

Dr. J. (John) Pierce
John Pierce is a scientist/leader who focuses on interdisciplinary, biotechnological approaches for improving the materials, energy, and agriculture sectors. A variety of commercially successful products have been brought to the agriculture, renewable chemicals and materials, and food sectors from research initiated by him and his groups. Most recently, as Chief Bioscientist at BP from 2010-15, he was responsible for positioning the company to gain maximum benefit from the application of biosciences to BP's world-wide businesses. This

involved strategy, building up internal research capabilities, engagement with outside companies, and oversight of extensive collaborations with universities. Prior to that, he worked at DuPont for a substantial time, commencing as a research scientist in Central Research and Development and culminating as Vice President for DuPont Applied BioSciences and Director of Biochemical Sciences & Engineering where he had responsibility for DuPont's biotechnology research and development efforts in the production of fuels, chemicals, and materials. Dr. Pierce received his B.S. degree in Biochemistry in 1976 from the Pennsylvania State University and his PhD degree in 1980 from Michigan State University in the areas of carbohydrate chemistry and enzymology, followed by postdoctoral appointments at Cornell University and University of Wisconsin. He has been a Lecturer in the Department of Biological Engineering at MIT since April 2013.

Throughout his career, Dr. Pierce has focused on the integration of biology with chemistry, engineering, and material sciences to create biotechnological applications in agricultural chemistry, plant genetics, and industrial chemistry. In addition, he has long been involved in a variety of public policy activities associated with public acceptance and governmental support of biotechnology.

Prof. dr. H.A. (Harm-Anton) Klok
Head of the Institute of Materials, Laboratoire des Polymères, Ecole Polytechnique Fédérale de Lausanne (EPFL) Lausanne (Switzerland).

Education

1989-1993	Studies of Chemical Technology, University of Twente (Enschede, The Netherlands)
1993-1997	Research and teaching assistant in the group of Prof. M. Möller (Organische Chemie III/Makromolekulare Chemie, Universität Ulm, Ulm, Germany) Topic of PhD Thesis: "Supramolecular and polymeric building blocks for the development of optical ion sensors"
2004	Habilitation on "Protein-mimetic polypeptides and protein-inspired hybrid block copolymers" and venia legend in macromolecular chemistry (RWTH Aachen, Aachen, Germany)

Academic record

1997-1997	Postdoc in the group of Prof. D. N. Reinhoudt (Laboratory of Supramolecular Chemistry and Technology, Department of Chemical Technology), University of Twente 1997 – 1999 Postdoc in the group of Prof. S. I. Stupp (Departments of Materials Science and Engineering and Chemistry), University of Illinois at Urbana-Champaign (Urbana-Champaign, USA)
1999-2003	Project-leader in the group of Prof. K. Müllen, Max Planck Institute for Polymer Research (Mainz, Germany)
2003-2008	Assistant Professor (tenure track) and director of the Polymers Laboratory (Institute of Materials), Ecole Polytechnique Fédérale de Lausanne (EPFL)
2008-2009	Associate Professor and director of the Polymers Laboratory (Institute of Materials), Ecole Polytechnique Fédérale de Lausanne (EPFL)
2009-2012	Director of the Section of Materials Science and Engineering (~ Director of undergraduate studies elsewhere).
2009-present	Full Professor and director of the Polymers Laboratory (Institute of Materials and Institute of Chemical Sciences and Engineering), Ecole Polytechnique Fédérale de Lausanne (EPFL)
2012-resent	Director, Institute of Materials (EPFL) (~ Department head elsewhere).

Awards, academic honours

- Talent-postdoctoral fellowship of the Netherlands Organization for Scientific Research (NWO). (01.12.1997 – 01.12.1998).
- Emmy Noether Fellowship of the Deutsche Forschungsgemeinschaft (DFG). (01.09.1999 – 30.04.2003).
- Thieme Journal Award, 2002.
- Arthur K. Doolittle Award, American Chemical Society (Polymeric Materials: Science and Engineering Division), 2007.
- Visiting Professor, University of Bordeaux, Bordeaux (France), July 2010.
- Chair Professor, College of Chemistry, Chemical Engineering and Materials Science, Soochow University, Suzhou (China), 2011 – .
- Visiting Professor, Department of Polymer Science and Engineering, University of Massachusetts Amherst, Amherst (USA), July 2012 and July 2014.
- Chinese Academy of Sciences visiting professorship for senior international scientists, Institute of Chemistry, Chinese Academy of Sciences, Beijing (China), 2012 - 2013.
- Guest Professor, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, Changchun (China), 2012 – .
- Guest Professor, School of Environmental and Chemical Engineering, Shanghai University, Shanghai (China), 2014 - .
- Visiting Professor, School of Materials Science and Engineering, Nanyang Technological University, Singapore, 2015 - .

Prof. Dr. P. (Paul) Attfield
Professor of Materials Science at Extreme Conditions University of Edinburgh.

Paul Attfield holds a chair in Materials Science at Extreme Conditions at the School of Chemistry, University of Edinburgh and he is the firector of the Centre for Science at Extreme Conditions. He received B.A. and D.Phil. degrees from Oxford University, and he was a Co-Director of the Interdisciplinary Research Centre in Superconductivity at the University of Cambridge during 1991-2003. He received the Royal Society of Chemistry's Meldola and Corday-Morgan medals and Peter Day award, and he was elected a Fellow of the Royal Society of Edinburgh (FRSE) in 2006 and of the Royal Society (FRS) in 2014. Early research contributions included pioneering resonant X-ray scattering experiments of cation and valence ordering, and studies of disorder effects in functional oxides. Current research is centred on electronic and magnetic materials; a recent highlight was the solution of the 70-year old 'Verwey' problem of charge order in magnetite - the original magnetic material.

Dr. R. (Rainer) Haag

Institut für Chemie und Biochemie – Organische und Makromolekulare Chemie, Freie Universität Berlin.

Education

1992 - 1995 Ph.D. thesis at the Institute for Organic Chemistry, Georg-August-Universität Göttingen (Germany) with Prof. Dr. A. de Meijere

1996 - 1997 Postdoctoral fellow at the Chemical Laboratory, University of Cambridge (England) with Prof. Steven V. Ley

1997 - 1999 Research associate in the Department of Chemistry, Harvard University, Cambridge, Massachusetts (USA) with Prof. George M. Whitesides

Appointments

1999 - 2002 Assistant professor (Habilitation) at the Institute of Macromolecular Chemistry, Albert-Ludwigs Universität Freiburg (Mentor: Prof. Dr. Rolf Mülhaupt)

2003 - 2004 Associate professor of Organic Polymer Chemistry, University of Dortmund

Since 2004 Full professor of Organic and Macromolecular Chemistry, FU Berlin.

05-08/2009 Visiting professor, Harvard University, Cambridge (USA), with Prof. David Weitz

Honors and Awards

2014 Honorary Life Fellowship (Indian Society of Chemists and Biologists)

2010 Arthur K. Doolittle Award (American Chemical Society, PMSE Division), Steinhofer Lecture Award 2010 (University of Freiburg)

2008 Director of the Collaborative Research Center SFB 765 on Multivalency (DFG)

2004 Nanoscience Award for Young Scientists from the Ministry of Science (BMBF)

2003 Dozentenstipendium of the German Chemical Industry (VCI)

2002 Heinz Maier-Leibnitz-Prize 2002 of the Deutsche Forschungsgemeinschaft (DFG)

2000 ADUC-Habilitanden-Award 2000 of the Gesellschaft Deutscher Chemiker (GdCh)

1997 Selected Member of the Studienstiftung des Deutschen Volkes

Synergetic Activities

- Organizer of the International Symposium on Polymer Therapeutics 2007 in Berlin
- Coorganizer of the International Symposium on Polymer Therapeutics 2008 in Valencia
- Organizer of the Polydays 2008 on Active and Adaptive Polymers, in Berlin
- Coorganizer of the Polydays 2010 and the GdCh-Fachgruppentagung "Makromolekulare Chemie"

Other Scientific Activities

Together with two colleagues the university start-up company Hyperpolymers GmbH was founded in 2001 for the synthesis and marketing of dendritic polymers. Due to time constraints, this enterprise was closed down in 2007. Leader and Advisor for school research projects (Jugend-forscht): Giant Soap Bubbles with Polymeric Additives.

Appendix 2: Explanation of the SEP criteria and categories

There are three criteria that have to be assessed.

- Research quality:
  - Level of excellence in the international field
  - Quality and Scientific relevance of research
  - Contribution to body of scientific knowledge
  - Academic reputation
  - Scale of the unit's research results (scientific publications, instruments and infrastructure developed and other contributions).

- Relevance to society:
  - quality, scale and relevance of contributions targeting specific economic, social or cultural target groups;
  - advisory reports for policy;
  - contributions to public debates.
  - The point is to assess contributions in areas that the research unit has itself designated as target areas.

- Viability:
  - the strategy that the research unit intends to pursue in the years ahead and the extent to which it is capable of meeting its targets in research and society during this period;
  - the governance and leadership skills of the research unit's management.

Category	Meaning	Research quality	Relevance to society	Viability
1	World leading/excellent	The unit has been shown to be one of the most influential research groups in the world in its particular field.	The unit makes an outstanding contribution to society	The unit is excellently equipped for the future
2	Very good	The unit conducts very good, internationally recognised research	The unit makes a very good contribution to society	The unit is very well equipped for the future
3	Good	The unit conducts good research	The unit makes a good contribution to society	The unit makes responsible strategic decisions and is therefore wel equipped for the future
4	Unsatisfactory	The unit does not achieve satisfactory results in its field	The unit does not make a satisfactory contribution to society	The unit is not adequately equipped for the future

Appendix 3: Programme of the site visit

Monday 14th September	**UT discipline Chemical Engineering**
9.30-12.30	review committee meeting
12.30-13.00	Lunch review committee
13.00-14:00	Meeting with management of Faculty, discipline and Research Institutes Dean: prof. Hans Hilgenkamp, Discipline chair: Prof. Julius Vancso, Scientific directors: MESA+: Prof. Jeroen Cornelissen, MIRA: p.rof. Albert van den Berg, Director TGS: dr. Paul van Dijk, Editor report: Dr. Ben Betlem
14:00-15:00	Delegation program leaders of the discipline Prof. Jurriaan Huskens (MNF), Prof. Rob Lammertink (SFI), Prof. Marcel Karperien (DBE) Prof. Sascha Kersten (SPT), Prof. Leon Lefferts (CPM), Prof. Kitty Nijmeijer (MST)
15.15-16:00	Delegation staff members / researchers Dr. Nathalie Katsonis (BNT), Prof. Pascal Jonkheijm (MNF), Dr. Mark Huijben (IMS), Dr. Jai Prakash (BST) Prof. Nieck Benes (IM), Dr. Wiebe de Vos (MST), Dr. David Fernandez-Rivas (MCS), Dr. Boelo Schuur (SPT)
16.00-17.00	PhD-students team Martin Bos (SPT), Roger Brunet Spinosa (CPM), Evelien Maaskant (IM), Rindia Putri (BNT), Jonas Schnittert (BST), Hoon Suk Rho (MCS), Sinem Tas (MST), Janneke Veerbeek (MNF), Kasper Wenderich (PCS).
17.00-18.00	Internal meeting review committee
18:00-18:15	Feedback by review committee

Tuesday 15th September	**Delft University of Technology**
8.30-9.30	Review Committee meeting
9.30-10.30	Meeting with institute management Prof.dr. Tim van der Hagen (dean) Prof.dr. Rob Mudde (director education and vice-dean) Prof.dr. Isabel Arends (department chair Biotechnology) Prof.dr. Michiel Kreutzer (department chair Chemical Engineering)
10.45-11.30	Meeting with the Management of Biotechnology Isabel Arends, Jack Pronk, Mark van Loosdrecht, Luuk van der Wielen, Patricia Osseweijer, Fred Hagen, Sef Heijnen
11.30-12.15	Staff members Biotechnology Ulf Hanefeld, Peter-Leon Hagedoorn, Pascale Daran-Lapujade, Yuemei Lin, Maria Cuellar Soares, Marcel Ottens
12.15-13.00	Lunch
13.00- 13.45	Management Chemical Engineering Michiel Kreutzer, Bernard Dam, Jan van Esch, Freek Kapteijn, Chris Kleijn, Ruud van Ommen, Laurens Siebbeles, Ernst Sudhölter
13.45- 14.30	Staff members Chemical Engineering Pouyan Boukany, Jorge Gascon, Ferdinand Grozema, Rienk Eelkema, Louis de Smet, Wilson Smith, Volkert van Steijn
14.45-15.45	PhD students Biotechnology and Chemical Engineering Dayinta Perrier, Bartek Trzesnieuwski, Eline Hutter, Anping Cao, Irina Prokopyeva, Maxim Nasalevich, Ana Olasolo Alonso (PDEng student), Carlos Cabrera Rodriguez, Susanne Sleenhof, Peter Mooij, Maaike Hoekstra, Ioannis Papapetridis, Ariana Bampouli (PDEng student)
16.00-17.00	Internal committee meeting
17:00-17:15	Feedback by Review Committee

Wednesday 16th September	**Eindhoven University of Technology**
8.30-9.30	Review Committee meeting
9.30-10.30	Meeting with Dean of the Faculty and Management of the Departments Prof. Frank Baaijens, rector magnificus, prof. Jaap Schouten, dean, professor René Janssen vice-dean, ir. Peter Janssens director of bachelor's and graduate programmes Chemical Engineering and Chemistry
10.30-11.30	Meeting with chairs Prof. Bert Meijer, prof. Albert Schenning, prof. Remco Tuinier, prof. Hans Kuipers, prof. Emiel Hensen, prof. Volker Hessel
11.30-12.15	Meeting with junior staff members Dr. Ilja Voets, dr. Stefan Meskers, dr. Jan Philipp Hofmann, dr. Niels Deen, dr. Johan Padding, dr. Timothy Noël
12.15-13.00	Lunch
13.00- 14.00	Meeting with PhD students Lana Borukhova, Jessica Clough, Bas van Genabeek, Matthew Hendrikx, Paola Granados Mendoza, Laura Kollau, Jose Medrano Jimenez, Roderigh Rohling
14.00- 15.00	Internal Committee meeting
15.00-15.10	Feedback Tu/e
15.10-17.00	Final meeting committee