The Research Council of Norway

Basic and long-term research within Engineering Science in Norway

Report from Panel 2: Products, Production, Project Management, Marine Systems and Renewable Energy

Evaluation
Division for Science

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The Research Council of Norway
P.O.Box 564
NO-1327 Lysaker
Telephone: +47 22 03 70 00
Telefax: +47 22 03 70 01
post@rcn.no
www.rcn.no/english

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Statement from the panel

The members of the Panel Number 2 for the Evaluation of basic and long term research within Engineering Science in Norway - Products, Production, Project Management, Marine Systems and Renewable Energy - hereby submit the following report.

The views presented in this report are the consensus among the members of the Evaluation Panel. The report represents an agreed account of the assessments and recommendations.

Ralf Preu (Chair)

Dimitrios V. Lyridis

Margareta Norell Bergendahl

Antonello Sala

Kristina Shea

Birgit Vogel-Heuser

Ulrich Jäger, Fraunhofer Institute of Solar Energy Systems, acted as the scientific secretary of the evaluation panel

1. Executive Summary

This report on the evaluation of the basic and long term research in engineering science covers topics from the fields of product design, engineering design, production, project management, marine systems, fishing and renewable energy for four different universities, one university college and three research institutes. The main part of the report is structured in three chapters giving an overall description and conclusions, general recommendations and description and evaluation of the institutions and research units. The participation of the individual research groups evaluated was mandatory for the university research units and on a voluntary basis for the groups attributed to research institutes and university colleges. Each research group was quantitatively assessed on their scientific quality and productivity as well as their societal relevance and impact. Further, general recommendations have been given especially dedicated to strategy issues concerning organization, funding, international collaboration, gender and mobility. The evaluation has been based on self-assessments using a given template, bibliometric data and interviews of all research entities as well as their organizational and governing bodies within their institutions.

The overall impression of the investigated groups was, on average, better than “good” with respect to scientific quality and productivity and “very good” with respect to societal relevance and impact. All interviewed groups made a very good impression in terms of motivation for their field and having a constructive discussion about their performance. This aligns well with their voluntary participation (except for the research units from university, see above), which is one point of criticism since it is likely that groups that underperform do not participate. Few groups evaluated showed outstanding scientific performance on an international level. Many groups currently have set their main objective as serving local, regional and national industry in direct collaborations as well as via the education of students with an average above international standards. A few individuals also achieve scientifically outstanding positions especially in niche areas related to the local industry, which is also internationally leading. It should be decided in general whether the national strive for outstanding scientific contributions should be followed by all groups or just a few and what level of trade-off with current support of local industry and education is acceptable. While as researchers we all try to achieve both, it is a great challenge. In our opinion, we propose the second option, i.e. encouraging some, but not all, groups to strive for international leadership in research. This would help to balance the different national interests in basic and long-term research, which most but not all research units seem to be very well aware off.

This approach is followed by the different calls for research center funding, which seems to be an appropriate measure to support the creation of excellent scientific contributions on an international level, e.g. the Ocean Space Center. Nevertheless, these centers are endangered by discontinuous funding, which should be carefully managed and monitored. Additional

measures that we propose include the installation of doctoral schools and scholarships, which have been found to be less common compared to international standards.

The funding situation of the evaluated research units is generally very good at an international level and enables, on average, very good infrastructure. In general, the good funding situation yields advantages for the quality of research. Nevertheless, we also have found that it creates, to some extent, a lack of insight about international competition and funding. Internationally proven schemes should be applied in order to improve on recruitment, especially international recruitment, gender balance and mobility.

Overall, the research units evaluated in this panel and the general research landscape gave a very good impression. However, internationally competitive research has to be pushed further including increasing the number of peer-reviewed journal publications that have significant impact. This should be supported by the national funding agency (RCN) while carefully monitoring the balance and trade-off with supporting local education and industry needs. It is recognized that such a change takes time and we observed a general willingness and desire of most groups to move in this direction.

2. Overall description and conclusions

2.1. General description of the evaluated research fields

2.1.1. Overview

The Research Council of Norway (RCN) has decided to evaluate research activities in Engineering Science in Norwegian universities and colleges. The report of the evaluation Panel 2 will form the basis for the basic- and long-term future strategy of the Research Council. The objective of this evaluation is to assess the quality and relevance of research and is expected to:

- Offer a critical assessment of the strengths and weaknesses of Norwegian research in Engineering science, both nationally and at the level of individual research groups and academic departments. This includes both the scientific quality of research in an international context and its impact on society.
- Identify research groups which have achieved a high international level in their research, or which have the potential to reach such a level;
- Identify areas of research that need to be strengthened in order to ensure that Norway in the future will possess necessary competence in areas of importance for the nation.

The evaluation included research groups from the universities of Agder, Bergen, Trondheim and Tromsø as well as the University College of Gjøvik and the research institutes SINTEF, MARINTEK and IFE. The research fields covered are product design, engineering design, production, project management, marine systems, fishing and renewable energy. The groups were graded with respect to their scientific quality and productivity (with a scale from 1, weak, to 5, excellent). Their societal relevance and impact was rated from A (very high relevance and impact) to E (very low impact and relevance). In either criteria, a 3 (“good”) or C (“good relevance and impact”) means that the group performs to the standard that is expected from a group in that field, see Chapter 5 of this report for more details. In our view, on average, the evaluated research fields performed better than good with respect to scientific quality and productivity and very good with respect to societal impact and relevance. This reflects the general self-understanding of the groups and their main objective to deliver well educated engineers to meet the demand of the Norwegian industry within their fields. There are just a few outstanding groups or individuals who strive for academic excellence. A graphical overview is shown in Figure 1.

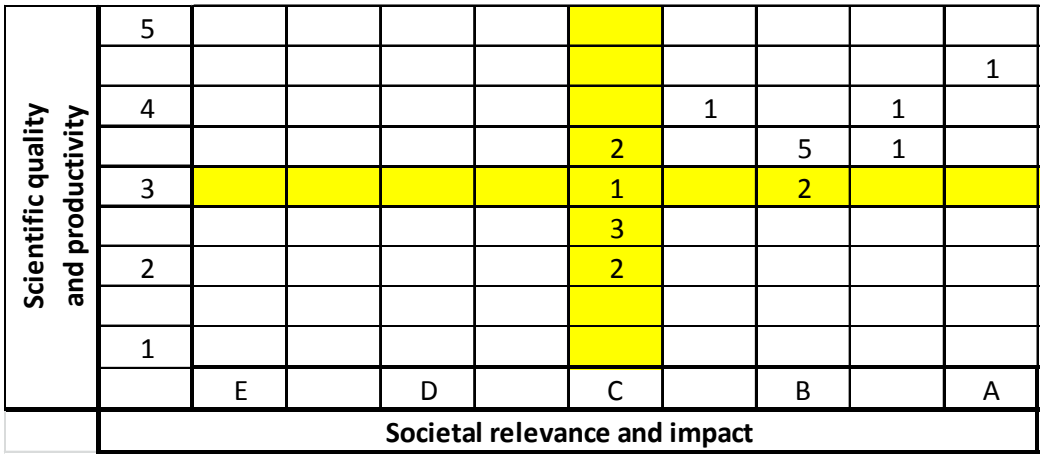

Figure 1 – Graphical overview of the given grades of the evaluation of Panel 2. The scientific quality and productivity is rated from 1 (weak) to 5 (excellent) and the (societal) relevance and impact is rated from E (very low) to A (very high). The overall arithmetic mean of all 19 evaluated groups of the scientific quality and productivity is between 3 and 3-4. The overall arithmetic mean of the relevance and impact is better than C-B.

2.1.2. General strengths and weaknesses of Norwegian Engineering Science research in an international context

According to the study carried out by the European Commission[1] (European Union, 2014), Norway maintains one of the highest spending levels on R&D per capita. The country's R&D intensity fluctuated slightly over the period 2007-2012, reaching a high of 1.76% in 2009 but remaining almost stable between 2010 and 2012, with an average annual growth rate of 0.7%. The knowledge-intensity[2] of the Norwegian economy remains below the EU average although it has been growing at a faster rate in recent years (+2.4% instead of +1% at the European level).

Internationalization has become an overall priority of the government's R&D policy in recent years in order to improve the quality of research. The new White Paper on research entitled *'Long-term perspectives – Knowledge provides opportunity'*, which was presented in March 2013, states that Norway should commit to strengthening the internationalization of its research system. Following this line, it has been requested that all activities of the Research Council of Norway (RCN) include clearly defined objectives and plans for international cooperation as well as international review of research proposals. To further enhance the quality of Norwegian research and higher education, it is important to maintain close contact with international environments. This has only been partly found within the strategic objectives of the assessed research groups.

[1] European Union, 2014. Research and Innovation performance. Innovation Union progress at country level in the EU. Publications Office of the European Union, Luxembourg, 364 pp

[2] Composite indicator that includes R&D, skills, sectorial specialisation, international specialisation and internationalisation sub-indicators.

The self-evaluation reports prepared by the departments and groups have been a valuable guideline before and during the evaluation. Adherence to a stricter format of the reports would have saved much time of the Panel. For example, the research output with publications of different categories (e.g. peer-reviewed journal publications, peer-reviewed conference papers, books and book chapters, and other, e.g. scientific project reports) of the groups could have been presented in a more systematic way allowing better comparison. One suggestion is that it is presented in the Norwegian point system and that this is clearly explained. Publication on an international scale still is not customary in all the disciplines/groups and this is reflected sometimes in the low publication scores as well as by the absence of patents and/or Patent Cooperation Treaty for many of the evaluated groups. This has been acknowledged by the panel. The publication output of most research groups should be improved. The emphasis is still too much on internal reports, national publications and on conference proceedings. Publication in well-selected international journals, preferably ISI[3]-listed, with high impact factor will have a beneficial influence on the fundamental part of the research activity of the groups. In order to be effective, such a requirement must however be accompanied by a clear policy and incentive structure also at Research Council of Norway (RCN) level.

2.1.3. Impact and relevance of the evaluated research with regard to the future needs of national and international business- and public sectors

In recent years, R&D policies and innovation strategies have focused on specific and representative areas of Norway's economy. These include the strategies for oil and gas, energy, climate, green growth, biotechnologies, nanotechnologies, and the maritime sector. On national level, there is also a broad political consensus on the need to foster R&D-intensive and knowledge-intensive manufacturing industries and services by exploiting both renewable and non-renewable energy technologies. The infrastructure of the research institutes significantly extends and enhances the capabilities of the departments of the universities. There is a fundamental contradiction between the assumed long-term research vision of the faculty and the direct application-oriented strategy of SINTEF. The role of SINTEF should be the shorter-term developer role while the scientific faculties should be responsible for the longer-term basic as well as applied research.

Some groups not only from university colleges defined their main impact as delivering students to industry, which will after some years certainly be in management positions. We, as an evaluation board, understand this argument but due to the fact that we are evaluating research impact, we cannot rate this with a mark higher than average.

[3] ISI – Institute for Scientific Information see www.isinet.com/

2.2. Impact of national excellence centers

Norway offers several programs to strengthen mid- and long-term research. These programs are partly governed and awarded by the Research Council. These excellence center programs are useful for directing excellent research in certain directions. Formal matters such as duration or funding volume of these programs will not be evaluated here, as this is beyond the scope of the panel.

- Norwegian Centers of Excellence (SFF) - the goal of the scheme is to establish time-limited research centers characterized by focused, long-term research efforts of a high international caliber. High scientific quality is the main criterion for the selection of the centers; however, researcher training is an important aspect as well. The SFF thus provide an excellent tool to steer the direction and also the intensity of basic research in the targeted areas. The Research Council has therefore a strong, however indirect, position in regulating such activities. It should therefore carefully consider the goals and scope of the SFFs in order to align with national targets.
- Centers for Research-based Innovation (SFI) – the scope of this program is to provide a platform for collaboration between companies and research institutions. The goal is to encourage companies to innovate through a greater focus on long-term research and make Norway an attractive location for international companies to establish their operations. Thus, it is more focused on output which will have an impact on society, as companies are expected to bring the innovations eventually into a product or a service. This program can used as well to influence the R&D market in selected industries and possibly speed up knowledge transfer to industry.
- Centers for Environment-friendly Energy Research (FME) – the objective of this program is to establish time-limited research centers which conduct concentrated, focused and long-term research of high international caliber in order to solve specific challenges in the energy sector. As the transition from fossil fuels towards sustainable sources in energy supply and transport is becoming crucial, these centers are expected to have increased importance in the future. Due to the amount of challenges in that field, however, a clear focus on selected activities should be maintained in order to ensure a high level research with international impact.
- Two other excellence center programs are industry led and provide funding for cluster activities, however these did not seem to play a major role in the evaluated groups: the Norwegian Centers of Expertise Program (NCE) is established to enhance sustainable innovation and internationalization processes in the most dynamic and growth-oriented Norwegian clusters. The NCE Program is jointly owned and implemented by the three main Norwegian innovation agencies: Innovation Norway, the Research Council of Norway and SIVA. The program Global Centers of Expertise (GCE) was established in 2014 and thus did not have any relevance in the evaluation so far.

Being awarded with an excellence center puts the research consortium in a strong position. It has the possibility to generate significant output in both scientific ways as well as creating impact on society and markets. The Research Council has with these programs effective means to enhance cooperation on national or even international level. It is difficult to assess since the selection criteria are not clear. Obviously such competitive programs are difficult to handle with respect to sustainability.

2.3. Research co-operation nationally and internationally

The panel asserts that due to the size of the country and the necessity of local universities and university colleges to support companies in R&D, the number of existing universities, when including also university colleges, is large compared on an international level. Though this might also be applicable for other smaller European countries, the panel understands that due to the specific subjects and needs in both teaching and R&D in in the Nordic countries (deep sea, maritime in cold water, oil and gas-specific challenges in mechatronics, automation, control and measuring techniques), this number is comprehensible. The application specific requirements seem to be unique and challenging and justify further research as well as adaptation of methods, models and technology. Due to this specialty, it is hard for most groups to find fitting co-operation partners with a strength in a similar field to create a scientific mid- and long-term win-win situation. The research collaborations target mainly the UK, US and Canada. It was not clearly understood why co-operation inside Europe and outside the Nordic countries seems to be under average.

National collaboration seems to be on an acceptable level. In some topics, cooperation should be enhanced or started, as expertise can be shared and synergies be exploited. The Research Council has excellent tools for encouraging collaborations on the national level with the possibility to award and fund national excellence centers.

2.4. Funding and infrastructure

Funding in Norway comes mainly from four sources: The State, the EU, national and international industry. The RCN plays an important role in distributing State funds to the various Universities, University Colleges and Research Institutes both directly and also through competitive research proposal applications. Funding from the Norwegian state is thus quite extensive. On the other hand, the EU also generously supports research through various funding instruments and via competitive procedures. Finally, the industry allocates funding on a case-by-case basis with very few long-term agreements. The nature of the national industry is in general such that it generates a lot of research requirements. The industry in general addresses these issues via the national research community.

With all these possibilities before them, Norwegian research groups are in a very good position in terms of funding possibilities especially when compared to groups located in other places in the world. To a great extent most of the research groups evaluated justify their

research output and impact sufficiently well, while a few have also impressive achievements. This means that research funding has been very successful until now and this support to the research community was essential in bringing Norwegian Research to a good-to-very good level, which it currently maintains.

But as in all cases, there are also negative points arising from this situation. First of all, it has become apparent that the affluence of funding for research (which is a national target) has allowed many research groups in Universities, University Colleges and Institutes to rely mainly on national funding that is easier to get or turn to the national and at times local industries. This is profitable in the short run, but in the long run it may be unsustainable: it slowly makes these groups acquire an insular mentality in research a fact that is also pronounced by the geographical remoteness, the climatic specificity, and the actual size of the country. In order to remain sustainably attractive for the national or local industry, which is internationally competitive, it is important to seek for a high international standing. Even though research may be insular, the industry, due to its extremely competitive nature cannot be insular and will eventually start seeking solutions internationally.

A second negative point lies in the fact that it is not entirely clear how national funding is distributed geographically or among research areas. Furthermore, it is not clear whether all groups conduct research according to well-defined national targets. In fact, many of them appear entirely focused on industrial needs, which in one sense is appropriate, but on the other hand it involves a heavy opportunity cost: it does not allow them to make internationally acclaimed basic research work that is also useful especially in the long run as it increases their open mindedness, their flexibility, their diversification ability and it establishes their scientific identity and competitive advantage at an international level.

Despite the fact that funding for research is ample, a lot of the groups voiced concern about non-existent or outdated physical infrastructure facilities. A few, such as NTNU, benefit from the close cooperation with the SINTEF Group (including MARINTEK), which allows them access to more modern facilities and gives them use of these for basic research, education and Ph.D. level work. Others, however, due to their remoteness (geographically), age (as many were only recently established at a research level), or size do not have the ability to acquire the required infrastructure for research thus hindering them from doing experimental research. However, some of the facilities that do exist in Norway are very significant even compared to those internationally.

Finally, but most importantly the forthcoming establishment of the Ocean Space Center will be central to the development of research in specific priorities and in funding infrastructure for a large number of research stakeholders.

All these issues put a significant responsibility on the shoulders of RCN in terms of funding for research, raising the international level of research and impact, and infrastructure

allocation and this will be, according to the panel, one of the major challenges to be addressed in the future years.

2.5. Training, recruitment, gender balance and mobility

2.5.1. PhD Training

PhD training is vital to all institutions, departments and groups wishing to increase their scientific output, productivity and recognition. Further, it is vital to recruit the best candidates to have an attractive and efficient PhD program. While most groups interviewed noted this, very few had either programs in place or detailed plans for the future to create such programs.

On reflection after the interviews, it is noticeable that many PhD students define their research topics on their own, in collaboration with one or more professors and have too little contact with students from related fields. The most exciting research advances in the coming years are likely to come from the interconnection of areas and research that operates across traditional boundaries.

The main recommendation is to organize doctoral schools in departments or at university level to set in place a new era of PhD training that will help Norway, universities and institutions achieve their goals in becoming international scientific leaders. The following suggestions are given for consideration when developing such schools:

- Common courses on basic elements for all in research, e.g. scientific theory, research methodologies and methods, literature research, carrying out experimental research, peer-reviewed journal paper writing, proposal writing, writing research plans, reviewing papers, effective participation in international conferences, language training, research ethics, and making both scientific and business presentations can be developed.
- Doctoral schools can connect students from different departments through joint seminars and programs, large and small, and clustering students with related interests. This has proven to be a very strong instrument to increase connections and also exchange general experience about the demands of a research career and the university. Further, it provides the faculty from different departments a reason for meeting.
- Regular exchange programs between Norwegian universities can be developed to enable PhD students to travel, in an economic way, to different universities. This could grow to international exchange, e.g. recommending or requiring a stay abroad during the PhD study.
- Common courses can also be offered on teaching aspects for those wishing to pursue an academic career.
- Academic career planning workshops and mentorship can also be included, some targeted specifically at female PhD students.

- In order to stimulate excellence in academic research, PhD scholarships should be set up to a reasonable level and based on a competitive call.

The effects that can be achieved through doctoral schools are a higher overall quality of research and publication output, transfer of knowledge and experience from more scientifically-oriented PhD advisors, more uniform supervision of PhD students, higher impact of research, better understanding of the academic world and career path, higher transparency, more contact with senior advisors from other environments, PhD advisors get to know each other, competition that could drive excellence, and new collaboration possibilities. Another effect is that these years in a doctoral school also form professional lifelong friendships with colleagues wherever they work in the future. This provides the initial professional network that is vital and will serve the PhD students later.

Further, experience and results show that this form of research education makes the PhD education more attractive to female candidates. It also attracts new categories of men. In summary, it helps to attract a more diverse group of people who are very motivated and encouraged to go through a PhD study.

2.5.2. Recruitment and Gender Balance

Besides PhD training, faculty recruitment is another corner stone to be successful in developing scientific and application-oriented research programs in engineering. In cases of departments and groups that are under transition, e.g. from teaching colleges to research universities, strategic recruitment involves identifying future research challenges and defining new areas that combine both potential for scientific research as well as, in many cases, relevance to local and national industry as well as society. The positions need to be advertised internationally and in a way that makes the positions attractive beyond Norway. Active recruiting and headhunting can also be effective. If and when hiring foreigners, integration programs need to be offered to successfully keep such people. Several of the groups we have met have presented successful recruitments. Still, there is more to be done on all levels.

A third corner stone to success is achieving gender balance, which is not only about ‘attracting women’ to the university, but also making the environments attractive to the most talented female scholars and places where they want to work. It is recognized that this is a difficulty for many universities and institutions in engineering and science. The first step is to develop a clear idea and argumentation about what benefits for all can be achieved through gender balance, e.g. research output and new research directions through a broader mindset. The second step is of course to consider under which circumstances the organization is willing to leave space for change and real influence. One does not need to start from scratch on this topic, but rather look to other studies and adapt them to the Norwegian and university

or institution context, e.g. the APS Best Practices for Female Faculty[4] and the MIT studies on female faculty in engineering and science[5]. Others also can be found.

2.5.3. Mobility

Mobility is defined here as exchange of people between universities, institutes and industry nationally and internationally. Scientific exchange and mobility can be fostered in the doctoral school mentioned already. The real need though is to enhance international mobility through research exchange and longer stays abroad, e.g. post-docs. In many places in Europe now it is nearly a requirement to have a one to two year post-doc abroad in Europe, North America or Asia before obtaining a faculty position. This could be achieved by utilizing the RCN mobility programs. It would benefit universities and institutes through the better training of people with a wider range of experience and a more global mindset.

With the very frequent contact that we have seen between the research organizations and industry in Norway there is a fantastic opportunity to increase more general mobility in the system, which could lead to benefits for both sides. Many departments and groups mentioned the current challenge to work with industry on more basic and long-term research, which is vital as they develop their scientific profiles to make the research relevant, and thus have an impact, on industry and society. Another common point was the high recruitment of Bachelor students in industry thus making it harder to keep top Master and then PhD students. It is recommended to develop further joint Master and PhD programs in collaboration with industry as a way to combat this and one type of important scientific education. There are a lot of benefits on both sides with developed exchange programs and eventually should result in increased relevance and quality of research and education.

[4] http://www.aps.org/programs/women/reports/bestpractices/female-faculty.cfm?renderforprint=1
[5] http://newsoffice.mit.edu/2011/women-mit-report-0321

3. Overall recommendations

3.1. General recommendations to policy makers / RCN

In this evaluation, the examining panel found that the overall performance of the assessed research groups is, on average, better than "good" in terms of scientific quality and productivity and "very good" in terms of societal relevance and impact. The panel suggests that the following points are taken into consideration:

- The non-participating groups should be encouraged, possibly required, and activated to take part in the upcoming evaluations.
- Some major, nationwide institution (e.g. The Research Council (RCN), and charity organizations…) should set up a PhD scholarship program for the promotion of excellent research and doctoral training.
- The public offer for a national or international award in one or more different disciplines in engineering science would help to promote and reward excellence. Awards are becoming increasingly important for all international universities.
- The role of the Research Council was found to be very helpful for research. The panel suggests that the RCN should continue its active support of Norwegian research and should in fact enhance its role to drive international excellence.
- It should be more clearly communicated what the major targets of Norwegian research are: what are the pillars according to which it operates and in the end whether specific industrial clusters can be identified that co-align with the Norwegian research area priorities. In this sense, for example, the establishment of the Ocean Space Center is a first class opportunity for the foundation of research for years to come.
- Large R&D infrastructure facilities should be submitted to a regular review in order to ensure being technically up to date and having a reasonable utilization rate. Focus of these facilities should also be placed on enabling excellent, unique research and not only serving short term needs of the industry. Large infrastructure facilities must be available for Norwegian parties.
- The RCN is encouraged to reassess the criteria according to which funding is allocated and how projects are evaluated. Even though it is understandable and legitimate that national funding may not be directed to international competitors, an additional major requirement may be placed for funding that research conducted should be, in some cases, internationally competitive and that researchers should make efforts to collaborate with and be active in the international scientific community.

3.2. General recommendations to groups / institutions

- The research groups and departments should enhance international cooperation and awareness. They should also consider trying to seek more funding from such sources, e.g. EU funding.
- The Universities are encouraged to seek establishment of "state or industry" sponsored chairs that will allow them to attract for a specific period important established researchers from the international community. This could foster a change in the scientific research culture to move the research towards more internationally competitive levels.
- Gender balance: please strongly consider the recommendations in Chapter 2.5.2 and put them into action. While quotas are not the only answer, achieving around 30% females in groups and departments is known to tip the balance and change the culture to then attract more women.
- The institutions/departments are encouraged to organize research education in a more structured way, e.g. development of doctoral schools, see chapter 2.5.1.
- The groups/departments should select co-operation partners for basic research by international excellence and strengthen co-operation also outside of northern Europe, e.g. to central and southern Europe, and more independently from industry application areas.
- An increased output of peer-reviewed journal papers is a goal of most of the assessed groups. All of them should publish more in ISI-listed journals and seek a greater impact of their publications. However, this requires planning research projects in a scientific way with identified research contributions upfront so that producing such papers is possible.

3.3. General recommendations for future evaluations

- Try to establish a common way of judging publication/citation performance: agree on one system (e.g. H-indexing), or use the established Norwegian point system and explain it to the panelists.
  The extracted parameters of the publications in the self-assessments should use the same criteria as the bibliometric data/analysis and their definite use should be enforced (See Section 2.1)
- Consider, whether a mandatory participation in such an evaluation for groups that receive substantial funding (e.g. above a certain amount of NOK) from the Norwegian Research Council is reasonable.

4. Description and evaluation of the Institutions and Research Units

4.1. Gjøvik University College

Gjøvik University College (GUC) has approximately 3000 students and 330 employees. GUC was established as a result of the reorganization of Norwegian higher education in 1994 when the Gjøvik College of Engineering and the College of Nursing in Oppland were merged into a single college.

4.1.1. Faculty of Technology, Economy and Management

Evaluation Units:
Sustainable Manufacturing

General comments on the department level:
The Faculty of Technology, Economy and Management (TØL) is one out of three faculties at the Gjøvik University College (HIG). They have two main areas, Sustainable Economy and Sustainable Manufacturing and have recently started a Master in Sustainable Manufacturing. TØL has the highest number of students and has historically been the main provider in the region of bachelor level education in engineering, mainly mechanical, civil/construction and electronics. A significant portion of time is spent on education, which is important for the region. Traditionally, HIG had little emphasis on research but is now moving into research and aims to become an international scientific leader.

The department works in the research areas of Sustainable Economics, Sustainable Manufacturing, Universal Design, Materials Technology and Renewable Energy. While they identify realistic targets for 2020 in terms of PhD students and new external funding, it will be difficult to simultaneously expand research programs in all areas to a good if not excellent international level given the resources and teaching load. TØL also targets to have four H2020 projects by 2020 and be coordinator for one. They have recently hired one professor with experience in EU funded projects.

Follow up from previous evaluations:
University College of Gjøvik was not part of the evaluation carried out by the Research Council in 2004.

Recommendations to the department/institution:

- While the faculty is currently diverse, the recommendation is to pick 1-2 research areas to focus on and first become excellent and internationally known in these areas before expanding to the rest. By doing this, the chances of success may be greater.
- If the target is acquiring more H2020 projects, the department is encouraged to strengthen their expertise both in defining and networking EU projects with scientific

colleagues and becoming active in promoting projects on EU level. They may think about hiring a member of staff, not a professor that is specialized in EU projects to take the organizational load off individual professors and increase their likelihood of success.

4.1.1.1. Sustainable Manufacturing

Description of the research unit:

The research profile of the group is currently very diverse including Life Cycle Assessment (LCA), renewable energy, wireless sensor networks, process monitoring, automation, quality and tolerance engineering, lean manufacturing and manufacturing information systems while also building up knowledge in additive manufacturing. Much research is focused on supporting local industry; they are currently involved in two FP7 projects and collaborate with NTNU and SINTEF. The group according to the self-report consists of 7 Professors, 3 Assoc. Professors, two of which are female, and 2 Assistant Professors. They are currently not allowed to grant PhDs but they would like to in the future. They collaborate with UiO, NTNU and Chalmers on their PhD student education and granting of degrees.

Strategy, organization and research cooperation:

The department has defined clear targets for 2020; however, the strategy to achieve these is unclear. They are in a transition process and still expanding their research profile. They recognize the difficulty to fit everyone and all activities under the umbrella “sustainable manufacturing” and also acquiring funding that fits as well. They are focusing on H2020 projects and it is encouraged to become more active and visible in the EU with colleagues working in the areas they want to develop, e.g. additive manufacturing through the addition of two new professors.

Scientific quality and productivity: **Grade: 2-3**

The group is in a transition phase to build up their scientific research. A big challenge is to do this given the current teaching load. Their strategy to do this is through PhD students in industry related projects (not granted within the period of evaluation). The current scientific quality and productivity is highly varied across the faculty with a few professors producing the majority of the output. They are aware of this, would like to develop more uniform output as well as more carefully select which publication channels are more important for impact. At the moment, it is the responsibility of individual professors to support journal paper writing and this is varied.

Societal and industrial relevance and impact: **Grade: C**

The group’s biggest impact to date is their students and collaboration with local industry. As much as 80 % of the research is industry based, thus leading to impact in these organizations.

Recommendations to the research unit:

- We strongly recommend increasing the scientific quality and productivity more uniformly in the group, especially level 2 (ISI-listed) journals, through new projects in core areas and rigorous planning and supervision of scientific goals in PhD projects.
- While the targets are clear, a strategy to successfully achieve them should be better thought out especially considering the group size and diversity of fields. It is recommended to focus on 1-2 areas and achieve (international) recognition in these areas first before expanding.
- In anticipation of being able to grant PhD degrees in the future, the group should start developing general courses on the group level on, e.g. scientific research methods and scientific writing of proposals and ISI journal papers. This would also help to develop PhD students that may be working with advisors who are not as strong scientifically. They will participate in a PhD School within the newly funded SFI but it is also recommended to take action directly themselves.
- The group should also seek to improve the recognizable impact it is having on industry and society through documented success stories of key projects.

4.2. Norwegian University of Science and Technology – Faculty of Engineering Science and Technology

The Faculty of Engineering Science and Technology (IVT) at NTNU offers more than 30 engineering programs in different areas. Master of Science programs are offered as well as a doctoral program. NTNU awards approximately 80% of all advanced engineering degrees in Norway and has therefore a major impact on engineering in Norway.

4.2.1. Department of Energy and Process Engineering

Evaluation Units:
Industrial Ecology

General comments on the department level:
The department's topic is one of the Megatrends of our society and century. The department is managed in a centralized way in decision making and budget. The department feels that the teaching load is too high (45% instead of 40%) to improve research output.

As a remark by the committee: the education workload is compared to other European countries below average, but the teaching burden seems to be lower in Norway, which is beneficial for research capacity.

Follow up from previous evaluations:
The department was evaluated in 2004 with a very high ranking for three out of four groups. The unit Industrial Ecology was founded afterwards and evaluated internally in 2011. The high rankings for all units were confirmed in the 2011 evaluation.

Recommendations to the department/institution:

- Start an internal process to include group leaders along with department heads for a more team decision making approach to avoid frustration and to shift responsibilities and authority to group leaders in a more cooperative management style.

4.2.1.1. Industrial Ecology

Description of the research unit:
The group worked on different important activities in industrial ecology, e.g. analysis of global resource use and emissions of human activities using Multiregional Input-Output (MRIO) models, assessment of environmental and resource aspects of technology and possibilities for sustainable development, often in the context of climate mitigation and overall sustainability, using life-cycle assessment and dynamics stock-flow approaches as well as assessment of bio-economy.

Strategy, organization and research cooperation:
The research group is officially formed in 2013 (coming from a "virtual group" within Thermal Energy) in one building, which helps a lot moving from a virtual group into a real

working group to gain synergy effects. There are successfully synergies between the professors visible and successful examples discussed in the interview. The centerpiece of the group's research strategy is to develop a joint computational infrastructure, i.e. combining different models, methods and software developed by different sub-groups and PhDs to gain an integrated framework of models and methods.

Scientific quality and productivity: **Grade: 4-5**

The research group gained synergy effects for different topics and in different projects. They have doubled their publication and they have built up valid and very good international academic co-operations. They have very good overall performance with some excellent individuals.

Societal and industrial relevance and impact: **Grade: A**

The group has a very high impact in the scientific community due to publications but also to society by involvement in policy making. Their contribution to scientific organizations including co-authoring the IPCC assessment report is acknowledged. The group has spun off two companies providing services and software within their field of expertise.

Recommendations to the research unit:

- Increase number of PhDs per professor to allow continuous growth.
- Support the increase of PhDs by cross group or cross department PhD coaching activities.
- We understand the importance of a computational framework, but focus should only be placed on this with view to a long-term research agenda.
- The challenge of maintaining the developed software implementing models and methods is necessary.

4.2.2. Department of Engineering Design and Materials

Evaluation Units:

Design, Analysis and Manufacturing (DAM)

General comments on the department level:

The Department of Engineering Design and Materials (IPM) within IVT at NTNU is one out of 10 departments in IVT. The Department carries out application-driven research within two groups, Materials and DAM (Design, Analysis and Manufacturing). The department runs ten laboratories and is managed by a core management team complemented with an extended management group securing participatory management. During 2010 the Department was reorganized into the two groups; previously four research domains were included. Projects are typically run by one to two professors, PhDs, and MSc students. For larger initiatives, for example EU projects, several groups collaborate. The department carries out a large amount of education and was previously, before 2010, focused on educational programs. Since then, they have worked to find new research project opportunities. The Materials group (evaluated by Panel 3 within this evaluation) has a high publication rate, though mainly delivered by

temporary researchers and post-docs. The DAM group is publishing mainly by FTE and is now in a transition phase with the intention to employ several new faculty members since some of the current staff are close to retirement. These faculties typically have a low publication rate and are historically focused on education.

Follow up from previous evaluations:

The department was considered as having too much focus on education in the previous evaluation, and has now followed the advice to put more focus on research, research education and scientific publication.

Recommendations to the department/institution:

- Since the scientific performance from the two groups in the department differs, there is a potential for combining scientific training of PhDs between the group so as to foster more uniform scientific research and output. One way could be to organize the PhD education in a way that students from the two groups share experience and develop their scientific skills together.

4.2.2.1. Design, Analysis and Manufacturing

Description of the research unit:

The DAM group conducts application-oriented research within the areas of 1) Product Development and Innovation, 2) Engineering Software Development/KBE, and 3) Select Manufacturing processes, mainly Metal Forming which has had a very strong track record. Several of the projects are multidisciplinary. Future plans are to focus on Product Development and Innovation in the early phases with strong links to the Materials group in the Department and targeting important Norwegian industry sectors, e.g. heavy industry, manufacturing and health. The size of the group is about 25 people, including 12 PhD students, effective 31.12.2013. The average age in the faculty is 52 years, the publication rate has increased and the ambition is a further increase, i.e. 3 publication points per professor not including PhD students. Most PhD students work closely with industry in their research projects and they are encouraged to write an article-based thesis. The group has a strong research funding base with RCN and industry as well as several EU projects. Both quantitative and qualitative research methods are used. The majority of the research is driven by industrial needs. The DAM group was recently awarded the KPD project TrollLab, an initiative to increase the capabilities of innovation and early-phase product development in companies including SMEs.

Strategy, organization and research cooperation:

DAM is now in a transition phase and the management team is working with renewal of the staff, recruiting new faculty members and better distributing and limiting the teaching load. Based on the departments recruiting strategy, the number of PhD students has increased after 31.12.2013. The group has high ambitions with the TrollLab. The overall strategy to define the future important research areas in the group should be done before searching for new staff

in order to have a positive impact on the group's overall scientific quality and output, which also has implications on which PhD students to attract.

Scientific quality and productivity: **Grade: 3**

DAM has clearly increased the publication production in the last years, though this work has to be continued with increased ambition for peer reviewed ISI-listed journals. To reach a higher degree of research output a more forward looking approach is needed to identify upfront potential scientific research contributions and key journals and try to match this with current industrial challenges. At this stage of the transition we have rated the average quality and productivity as a grade 3, Good, recognize the potential to improve this in the near future if taking a more scientific approach.

Societal and industrial relevance and impact: **Grade: B**

DAM works closely with industrial companies illustrating that the industrial partners find high relevance in working together with DAM. It is more difficult to judge specific impact based on the material given. We have though rated the relevance and impact of the DAM research as above the expected standard internationally to be expected from a research group in this field.

Recommendations to the research unit:

- Put more effort into strategic development of the future vision and scientific research areas that can be coupled with industry needs.
- Consider the definition of the new professorship vacancies in light of long-term need to improve the scientific research profile of the group and prioritize. Develop the diversity in the faculty including female professors.
- We propose a discussion on extended collaboration with both the Department of Product Design and with Department of Production and Quality Engineering, which might lead to some structural changes or a broader scope included within TrollLab.
- Continue to increase the scientific publication, e.g. through rigorous planning of scientific contributions in PhD projects.

4.2.3. Department of Marine Technology

Evaluation Units:

Marine Systems

General comments on the department level:

The department is organized into two research groups Marine Structures (evaluated by Panel 3 within this evaluation) and Marine Systems after reorganization in 2001 of its initial four departments. The academic staff consists per 31.12.2013 of 28 full positions, of which 18 are full professors, 3 associate professors, 6 researchers with PhD-degree and 1 university lecturer. Currently, there are 5 postdoctoral fellows and 101 PhD students at the department. It cooperates closely with MARINTEK with which it shares laboratory facilities, but it also maintains a Rolls Royce University Technology Center (RR UTC). Research strategy is clear

and takes place at multiple and distinct administrative levels. Furthermore, the scientific staff is continuously motivated to pursue a quantity and quality of scientific output. This is done both through incentive arrangements, travel funding for conferences, and even through start-up funding. It promotes invitation of external staff and sabbatical leave for own staff. It further promotes collaboration and more horizontal integration of the research groups as well as student involvement in research. Finally, creation of industrial activity and spin-offs are encouraged via stimulating among other things entrepreneurship among students. The evaluated group has recently improved its scientific performance substantially.

Follow up from previous evaluations:

The 2004 panel recommended a far more deliberate attitude towards scientific production. The panel further recommended research groups to produce research reports in which research outputs and achievements are recorded on an annual or biannual basis. An annual report is now produced by the department of Marine Technology, and in its larger centers, in order to report the scientific production and other important activities. Taking into account the bibliometric data and the provided self-evaluation, one group of the two has maintained its outstanding status, the second has performed averagely. A renewal of personnel, a more aggressive publication strategy and the target of an SFI has eventually paid off since 2004.

Recommendations to the department/institution:

- The Department should continue to pursue a policy of hiring younger, new, international and dynamic people and adopt a more balanced mix between male and female employees.
- It should also try to secure the funds for maintaining its infrastructure.
- The department should try also to provide a more autonomous position for itself but should not neglect the benefits of collaborating with MARINTEK.
- It should encourage even more international visits from abroad and encourage its staff to visit foreign universities.

4.2.3.1. Marine Systems

Description of the research unit:

The Marine Systems Research Group is one of two groups at the Department of Marine Technology, NTNU. The group was formed by merging the two departments Marine Design and Marine Engineering, in parallel with the Marine Structures Group being formed by the merger of Marine Construction and Marine Hydrodynamics in 2001. The Marine Systems research group covers the main areas marine design and logistics, machinery, operations, and marine resources and fisheries. Among other things, the group has coordinated one of the recent SFI applications and has taken an active role in the development of several new applications. The research activities of the group are within the core research strategy of the department and the faculty. Also within this group, some of the key areas are undermanned and will be strengthened as part of the realization of the strategic personnel plan and part of the research targets set by the group for 2018. The academic staff consisted per 31.12.2013 of

9 full time positions, of which 6 are full professors, 2 associate professors, and 1 university lecturer. This will be further strengthened.

Strategy, organization and research cooperation:

The group has a very well laid out and precise development strategy. The major aim is to be internationally recognized and nationally leading in applying and combining a broad set of system analysis and management methods with basic naval architecture and first principles methods for the design and operation of complex marine systems. The methods in focus span different system levels (chain, fleet, vessel/rig/facility, systems and subsystems), and integrate multiple high-level performance aspects (technical, economic, risk, and environment). The group has further selected a limited number of key strategic research goals towards 2018: risk and safety management of marine systems; multi-level design of complex marine systems; design and verification of complex energy systems; and sustainable arctic shipping. It will complete its staff renewal process and it will promote further collaboration internally, externally, and in teaching. This shall include common plans/strategies for projects, co-publishing, co-supervising, as well as adjunct professorships. The group strategy and organization conveys the confidence that goals will be met.

Scientific quality and productivity: Grade: 4

The group has performed much above average in the past five years. Scientific output has been mainly of high quality and in line with the group's research targets. In fact at least one of its members is recognized internationally as one of the leaders in his field of expertise. There are, however, still members that need to increase their scientific productivity especially in terms of quantity, as the group's output is not balanced. The research group (although this is not a suggestion for restructuring) is still diverse in its fields of activity as a result of the organization. Staff renewal in the next few years will most certainly assist towards this goal, as will also the well laid out research and publication strategy, and the extensive collaboration with international leaders in the field and the relative experience of some of its members. This strategy has already borne fruit and there is lately a significant increase in scientific productivity. Finally, the group participates in interdisciplinary and international work actively.

Societal and industrial relevance and impact: Grade: B-C

The research group has maintained a strong relation to the maritime industry in Norway, as well as relevant public and governmental organizations. This includes an extensive collaboration with industry partners in projects, both in terms of financial contributions, as well as active participation and results implementation. There is a set of industry funded projects that the group participates, however, the impact of its work as a group still needs further improvement.

Recommendations to the research unit:

- The scientific quality and quantity must become more uniform across the group.

- Incentives must be given to attract Ph.D. students as well as professors from Norway or abroad.
- Although close cooperation with MARINTEK is beneficial, the group should also try to establish an own, autonomous, and clear identity.
- Staff renewal process should continue without hesitation.
- Publication strategy with respect to quantity, quality, and uniformity across the group should also be actively applied.

4.2.4. Department of Product Design

Evaluation Units:
Product Design

General comments on the department level:
The Department of Product Design within IVT at NTNU is one out of 10 departments in IVT and was established in 1994. Since the department only includes one group, Product Design, it will be described in the group section.

Follow up from previous evaluations:
The 2004 report recommends that the department come out of isolation and strengthen research. It did not give a grade for Scientific Quality and Productivity. Since then, the group is now connected internally to the Design, Analysis and Manufacturing group, e.g. through joint PhD and Master student supervision, e.g. the CERN project, with Martin Steinert and are bidding to host the Nord Design conference together. There are also ongoing discussions about joining the two groups. Further comments on this point and scientific quality are found below.

Recommendations to the department/institution:
- *Since the Department and group are the same, the recommendations will be made in the next section*

4.2.4.1. Product Design

Description of the research unit:
The Department carries out research in five areas: 1. Interaction Design, 2. Design for Sustainability, 3. Systems and Service Design, 4. Design Education Research, 5. Applied Aesthetics in Design. The focus is on the first three with emphasis on overlaps between them whereas the latter two are exploratory to try to turn existing significant workload in teaching into research as well as activate more senior professors in research. The group consists of 1 Professor, 7.5 Assoc. Prof and 1 Assistant Prof with 1 Professor and 1 Assistant Prof. appointed in 2014. The Department has a significant teaching load in both the Bachelor and Master programs reporting 80-90% teaching load of most professors. The department is active nationally and internationally, for example they hosted the International Engineering and Product Design Education (EPDE) conference in 2010 and in 2014 hosted the International

Sustainable Development Research Conference. They also support some mobility and exchange of PhD students and staff.

Strategy, organization and research cooperation:

The department has a well thought out strategy of how the research areas fit together as well as targeting application areas towards the Norwegian industry. They also stated that they have 8-10 project proposals underway some aligned with the 10 strategic areas identified by NTNU. The department is run by a management team with regular department meetings including students if relevant. The department has a 50:50 ratio of male to female students and 2/3 female PhD students but has only started to attract more female professors. This should be continued to be addressed in the future.

Scientific quality and productivity: Grade: 3

While there are 10 Professors in the department, only about four to five are involved in research. This impacts greatly the overall quality and productivity of the group, which is recognized. It is a goal to change this through additional PhD students since the staff has significant teaching loads and thus too little time for research and writing scientific journal papers. They would need additional positions to improve. They are, however, internationally competitive in the area of Design for Sustainability through the arrival of Prof. Boks, which is perhaps their strongest research area. There is a significant increase in scientific work since 2004 and new hires and can be perceived to be in line with the field.

Societal and industrial relevance and impact: Grade: C

The biggest impact evident from the interview is that of their students as well as informal feedback from workshops. The target application areas for their research are highly relevant for industry.

Recommendations to the research unit:

- We strongly recommend to keep increasing the scientific quality and productivity more uniformly in the group, especially level 2 journals, through new projects and rigorous planning and supervision of scientific goals in PhD projects.
- While the strategy is well thought out, the group should strongly consider getting first critical mass in a few areas to become internationally known and leading. This can also be achieved through increased involvement in the international communities, e.g. Design Society.
- We propose a discussion on extended collaboration with the Design, Analysis and Manufacturing unit.
- The group should also seek to improve the recognizable impact it is having on national industry and society through documented success stories of key projects.

4.2.5. Department of Production and Quality Engineering (IPK)

Evaluation Units:

Production Systems
Production Management
Project and Quality Management
Reliability, Availability, Maintainability and Safety - RAMS

General comments on the department level:

The Department of Production and Quality Engineering (IPK) within IVT at NTNU is one out of 10 departments in IVT. The Department is performing research within four research groups, 1) Production Systems, 2) Production Management, 3) Project and Quality Management, 4) Reliability, Availability, Maintainability, Safety. Before 2012 IPK had three groups, but was reorganized after recommendations to get better research focus in respectively 2) and 3). The group performs a lot of contracted research, today like 2/3 of the projects, but is heading for 50 %. The Department is working to better meet the requirements for EU 2020 funding, but has difficulties with resources to meet the demands, for example difficult to find the right PhD students in time. The groups work relatively independent, but the work with SFIs will hopefully change this and increase the collaboration within the Department and with other Departments. Today there is no synergy between the groups within IPK. There is a current initiative to organize the PhD students in research schools. The initiative has been started with the ambition to further implement in the groups within IPK, the PhD school support for example writing proposals, promote exchange. The Department co-operates with Product Design and with Product Development in different projects. The department has an important role in continuing education.

Follow up from previous evaluations:

The IPK department was evaluated by RCN in 2004 and conducted an internal evaluation in 2011. The recommendation from 2004 was that image building on manufacturing should be a top priority and that management of strategic matters should be improved. IPK has followed the recommendations and strengthened one group, split another into two.

Recommendations to the department/institution:

- It is unclear to the reviewers, to which group knowledge discovery laboratory and the relevant topic of “intelligent fault diagnosis and prognosis system for condition-based management” lead by Prof. Kesheng Wang is assigned to. It is strongly encouraged to enhance the use and visibility of this important field.
- The department should make use of and further develop the PhD school for the whole department.

4.2.5.1. Production Systems

Description of the research unit:

The Production systems group performs research in Robotics and Mechatronics, Machine Tools, Subsea Control Systems and Laser Technology. They are coordinating and integrated project on Zero-defect manufacturing under the Factory of the Future of FP7, and are participating in several proposals for SFI from 2015. The group is to be developed and new staff (incl. professors) recruited, the new leader is recruited from industry, new PhDs are to be hired with an ambition to increase the number of PhD per faculty. The group builds on the consensus that production in Norway will require significant innovative development within production technology, robot automation, laser welding, additive production and metrology. The group is to develop new methods and technology, and graduate master students within the field. There are several patents and spin-off business coming from this group.

Strategy, organization and research cooperation:

The Production systems group is in a transition phase; new people are to be recruited. The strategy for development must be well anchored in the research teams, the permanent staff now is small and the ambitions within many areas are high. It is an obvious risk that the best performing professors in scientific publications are to be retired, thus the average publication production will decrease substantially. This fact has given impact on our judgment of the scientific quality and productivity due to lack of robustness. International research co-operations are not clearly visible; a strategy seems to be missing.

Scientific quality and productivity: **Grade: 2-3**

The Production systems are working both with contracted research and scientific research, thus giving effects on the performance of scientific outcome in terms of journal publications. With the current ambition and the new recruitment scheme the production systems will have a good potential to reach a good or very good quality in the coming years.

Societal and industrial relevance and impact: **Grade: C**

The projects within the group are conducted in the context of industrial applications and quite some funding are received from external partners. The more clarified impact or changes in industry or society is not shown, why we have judged the relevance and impact from the group as to be expected from a research group in this field.

Recommendations to the research unit:

- When implementing the new strategy of the group – consider the need for diversity within the team, including gender balance.
- Put more effort into setting priorities and focus when developing the strategy.
- The benefit with hiring PhD directly as Assistant professors should be mirrored in the risk to become too internal in recruitment and hinder the staffs' personal development.
- Increase the ambition concerning research on radical new technologies in the group, and focus on increasing the production and quality of scientific publications.

- Develop a clear strategy for international co-operation.
- Develop a more detailed mid-term and long-term strategy to focus your research inside robotics and make it visible for other departments.

4.2.5.2. Production Management

Description of the research unit:

The Production Management group was established in 2012 after a split from a larger group, and is performing research within five areas: 1) Manufacturing logistics, 2) Supply chain management, 3) Manufacturing strategy, 4) ICT technology and application in logistics and SCM, 5) Systems Engineering and applications of systems methods. They work mainly together with engineering industries (ship, oil, gas), manufacturing and retail. The current size of the group is 13 people including 7 PhD students; an increase is to come the coming years (new PhD students this year). The group does not have extensive laboratory facilities. The group has many research collaborations with national and European research projects, and collaborates with other groups within IVT. SINTEF is another close collaboration partner, and three of the professors have had senior positions there. The group is participating in a global master program.

Strategy, organization and research cooperation:

The Production Management group has a well functional management structure, with a flat organization, with distributed responsibilities stated in the job descriptions. The group shows, compared to other groups, a very good diversity referring to age, gender and nationalities, and a reflected plan when recruiting to increase team performance. They support exchange and collaboration programs and research school activities. It would be beneficial for the group and their performance with some more PhD students, as the capacity is there.

Scientific quality and productivity: **Grade: 3-4**

The Production Management group has made good progress relative to the size of the group and is contributing to international and national research. There is still potential to increase both productivity and quality of the publications, changing from the publication used within commissioned research for example in SINTEF collaboration.

Societal and industrial relevance and impact: **Grade: B**

The Production Management group works closely with industry on ‘real world challenges’ and management practice, which make us perceive that the impact is direct and the relevance proven, on a level above standards to be expected for a group in its field.

Recommendations to the research unit:

- Continue to increase the quality and productivity strategically of scientific publications.
- Increase the number of PhDs per faculty and develop the research school ambitions.
- Keep and disseminate the good diversity practice to other groups.
- Restructure the education for higher efficiency.

4.2.5.3. Project and Quality Management

Description of the research unit:

The Project and Quality Management group is conducting applied research concerning 1) Management of challenging projects, 2) Early warning in projects, 3) Organizing project-oriented work, 4) Blended learning within project management. The group size is about 17 people, 50 % being PhD students, and representing a number of educational backgrounds. The group is working actively with industry, running a larger network including industry and the public sector, Project Norway. The group has also established an active collaboration with project management researchers from other Departments in NTNU, and together with them developed both research and education activities.

Strategy, organization and research cooperation:

The Project and Quality Management group was established 2012 and has developed a strategy permitting relatively strong outreach compared to the number of staff – the key is the many collaboration commitment and many international cooperation partners. They do perform quite some commissioned work together with SINTEF – more like consultancy work. The group has quite good access to research funding and need to employ attractive PhD students. Two new permanent positions are to be employed in the near future.

Scientific quality and productivity: **Grade: 3-4**

The grade reflects the output in the evaluation period. The Project and Quality Management group has clearly increased the publications, especially the last year, though not included in this evaluation (until 2013). We perceive the group to be on its way to establish a strong scientific arena both nationally and internationally within the area of Project Management.

Societal and industrial relevance and impact: **Grade: B**

The strong networking activities and action research work performed by the Project and Quality Management group ensures an understanding of what are the relevant issues in practice. The possibility to make real impact is thereby large, and we judge the level to be above standards to be expected for a group in this field.

Recommendations to the research unit:

- Do more to combine qualitative and quantitative research, being a potential to increase in journal publication (data is probably available).
- Exploit existing data, often possible to make several publications from one data set.
- Put more emphasis on publication in renowned journals and other activities to be more visible and challenged in the international context.
- Continue to increase the ambitions on quality and quantity of scientific publication.

4.2.5.4. Reliability, Availability, Maintainability and Safety - RAMS

Description of the research unit:

The group focus is set on four research areas, i.e. reliability assessment of safety critical systems, reliability engineering, risk – based maintenance planning and risk analysis. The RAMS group is active within the research area reliability assessment of safety-critical systems.

Strategy, organization and research cooperation:

The group is well organized and in a continuous but smooth growth due to their excellent work. Three professors are funded by industry, i.e. 1 full time professor for 5 years and 2 adjunct professors at 20% which underlines the relevance and impact of their work to Norway but also internationally.

Scientific quality and productivity: **Grade: 4**

The group is well connected with many of the leading international experts. They still profit from their team of experts compared to single researchers worldwide. The publication quality is very good, the citation rate is above average, but the number of journal publications could be increased by including more PhDs as well as the individual H-factors.

Societal and industrial relevance and impact: **Grade: A-B**

The group is making good impact by providing fundamental books and working in standardization committees in the domain. Furthermore, their methods and results are used in different application domains and recently started to be transferred into new areas, i.e. transportation. The possibility to make real impact is thereby large, and we judge the level to be above standards to be expected for a group in this field.

Recommendations to the research unit:

- Increase number of PhDs per professor to allow continuous growth and increase publication rate as well as capacity for cooperation with other groups and departments.
- Continue coaching of PhDs to decrease drop output rate in cooperation with departments PhDs activities.
- Increase cooperation with Product Design and Product Development at NTNU and its visibility to further increase impact.
- It may be beneficial for NTNU and the department if the group is willing to widen their scope especially regarding maintenance planning, which is an upcoming topic in Europe addressed in many domains, e.g. chemistry, paper industry and steal industry as well.
- Increase journal publications in peer-reviewed ISI-listed journals.

4.3. University of Agder

The University of Agder (UiA) has the department of engineering science taking part in the evaluation. UiA was transformed from a University College to a university in 2007.

4.3.1. Department of Engineering Sciences

Evaluation Units:

Mechatronics
Renewable Energy

General comments on the department level:

The Department of Engineering Science was established in 2007 and is the largest of the four departments of UiA with more than 1200 students. The department has three main research groups in Mechatronics, Renewable Energy and Civil engineering and Offshore Construction. The first two are part of the evaluation by this Panel. The department is in the middle of a major shift, substituting a range of retiring traditional teachers with younger researchers. The department will focus research on the demand of local industry, which is being active on the global market, e.g. in the area of automation of drilling and robotics durability. The department takes great responsibility for developing the region and interacting with local industrial companies to understand their research needs. Further, they serve to educate the engineers in the area reporting a five times increase in need in the region recently. Very recently, the department has been successful in applying for an SFI. The department's strategy is to build up groups one at a time to ensure a good level of quality. To motivate and attract students for research they are writing papers stemming from student projects together with PhDs and submitting these successfully to conferences, where they present their work. The department co-operates with leading international universities, e.g. RWTH Aachen.

Follow up from previous evaluations:

The University of Agder was not part of the evaluation carried out by the Research Council in 2004.

Recommendations to the department/institution:

- The number of PhDs should be increased as mentioned in SWOT list up to 2-3 per potential supervisor.
- The Mechatronic group is currently the strongest. It is recommended to identify the next group to focus on for improvement.

4.3.1.1. Mechatronics

Description of the research unit:

The mechatronics group performs research in the following four areas: 1) robotics and automation control applications, 2) hydraulic and electric drive technology especially for

offshore systems, 3) dynamics and machine dynamics including destructive and non-destructive testing as well as 4) applied mathematics.

Strategy, organization and research cooperation:

In between the four research sub-groups, extensive communication is necessary (see SWOT analysis) to gain interdisciplinary understanding and develop joint strategies. The group benefits from the collaboration with renowned researchers from NTNU and RWTH Aachen, Germany. The group is successfully involved in RCN, EU-FP7 as well as NORCOWE funding. Many professors are strongly connected to companies and part-time employed in companies to help them define their R&D needs and support them by sending students. The external PhDs are closely supervised by UiA. The group struggles in improving the quality of Bachelor students and keeping qualified candidates for a Master course. In order to improve recruitment of master students, companies' sponsorship of students is allowed and supported. National and international research cooperation has been established, anchored in relations on personal level. To increase the number and the quality of students, students' exchange programs are organized, e.g. Austria, Australia and US. They should seek higher quality partners in the future.

Scientific quality and productivity: Grade: 3-4

The group managed to motivate nearly all professors to be part of the publication strategy, having one group member who is outstanding. The team based publishing approach is to be highlighted as successful. The strength of the individuals is taken for the benefit of the whole group accepting the unbalanced situation regarding published papers and PhD students in one sub-group.

Societal and industrial relevance and impact: Grade: C

The projects within the group are conducted in the context of industrial applications, and quite some funding is received from external partners. As a main impact to industry and society, the delivery of 150 Bachelor and a rising numbers of master students has been mentioned during the interview, because they will become decision-makers in these companies very soon. Further, they seek to work with companies to identify and carry-out joint PhD projects.

Recommendations to the research unit:

- The impact of research was not seen in this period of the major change from a university college to a research-oriented university. Thus, the group needs to develop a more advanced strategy to build up international research networks, fitting to their competences, strength and weaknesses.
- It is impressive to report 290 peer-review journal / monograph publications of one individual researcher in the evaluation period. However, only a portion of these are ISI-listed. The group should aim at peer-reviewed journal publications in ISI-listed journals and increasing the impact, i.e. citations, of papers rather than quantity. They should also seek a balance in publications among all colleagues.

- The group is encouraged to develop a clear research roadmap driven from their side but in collaboration with industry rather than wait for industry.

4.3.1.2. Renewable Energy

Description of the research unit:

The Renewable Energy Group performs research in three units: 1) Energy Materials, 2) Energy Systems and 3) Bioenergy and Thermal Energy. Renewable Energy is a very broad field and these topics reach a large part of this field. The research in the first two units is focused mainly on solar energy and its integration into the power grid, i.e. photovoltaics, thermoelectric generators and decentralized power generation and distribution. The group has researchers (6 professors, 9 associate/adjunct professors, 10 PhD students) partly with international background and cooperates with regional industry and international research institutions.

Strategy, organization and research cooperation:

The research units are free to develop research activities in close cooperation with industrial and academic partners. A reduction of teaching load is claimed to be important in order to improve research output. In general, the focus on demand-oriented research is too broad to reach the critical mass needed to achieve high quality contributions. After setting up the base for education, the strategy for research has not yet been clarified sufficiently for a university group. Nevertheless, substantial progress in staff recruitment is recognized, especially internationally through headhunting, with a good age mix, however still missing gender balance.

Scientific quality and productivity: **Grade: 2-3**

The scientific quality is good and generally consistent among the researchers submitting CVs in the unit, but the overall productivity of the majority of the professors should still be improved. The number of PhD students has been increased substantially and has now reached an acceptable ratio with respect to the number of researchers, thus a positive trend is expected.

Societal and industrial relevance and impact: **Grade: C**

So far, the societal and industrial relevance and impact is mainly limited to the education of students and support of regional industry. However, direct indication of success with regional industry is not clear and sustainability of cooperation with industry has been limited, so far. The successful contribution to international (mostly EU-funded) projects is recognized. Due to the importance of the field and the recent growth, a positive trend to improve relevance and impact can be expected if the right measures are taken.

Recommendations to the research unit:

- A research strategy should be developed to create a clear identity and produce excellence in well-defined areas. Nevertheless, a good network to the regional industry should be maintained.

- The field of photovoltaic energy systems and bio energy should be strengthened with a specific focus on applications in high latitudes. A detailed study on the demand for dedicated scientific testing infrastructure should be undertaken.
- The group should seek support for solid national and international collaboration to use the very good infrastructure available in other research labs, e.g. IFE in the field of photovoltaic materials.

4.4. University of Bergen

The UiB, 3500 employees and 14.300 students, is organized in six faculties, thereof the faculty of Mathematics and Natural Sciences (MNF) is sub-divided in eight departments, one of these being the department of physics and technology.

4.4.1. Department of Physics and Technology

Evaluation Units:
Measurement Science and Instrumentation

General comments on the department level:
The department of Physics and Technology (IFT) is involved in six centers, several of these being organized within Christian Michelsen Research, which follows the mission of "Research for industrial development". The whole UiB and the IFT therein follows a strategy to spin-off commercial activities. The department is structured in a matrix, in which seven research groups and areas each are interlinked, using the department council as a representation of the most important member groups of the department. A strategic plan was set up for the period 2011-2015 with the main focus on improvements of quality in research, education and innovation. The current plan further prioritizes amongst other points the consolidation after a phase of expansions into new areas as well as improvements of publication volume in peer-review journals, to strengthen international collaborations, mobility and gender balance. A new plan has just recently been released but was not part of the self-assessment. The department has a long-term strategy to recruit personal from different sources and encourages mobility.

The matrix structure is assessed to be appropriate for the department. According to the numbers of the self-assessment, the ratio of permanent to non-permanent staff has to be assessed to be critically low.

Follow up from previous evaluations:
The University of Bergen was not part of the evaluation carried out by the Research Council in 2004, but in the one for basic physics in 2010. They acknowledged the recommendations from that evaluation and implemented changes accordingly.

Recommendations to the department:

- The department head is new and should emphasize a balanced strategy. He should seek support and should be strengthened by the university in order to achieve funding to balance the matrix structure, basic research as well as the ratio of permanent and non-permanent staff, e.g. by increasing the number of professorships.

4.4.1.1. Measurement Science and Instrumentation

Description of the research unit:

Measurement science and instrumentation is a research area and part of the matrix structure within the department. It is interlinked with the research groups of acoustics, nano-scale physics & electronics, space and subatomic physics. There are five professors and two adjunct professors, and approximately one PhD per professor. Recruitment is international. For the past 8 years, The Michelsen Centre for Industrial Measurement Science and Technology has been important for the group in reaching its goals. This is an innovation center under the national scheme "Centre for Research Based Innovation" which was established in collaboration with Christian Michelsen Research in 2007.

Strategy, organization and research cooperation:

The group strategy is rooted in the department strategy and quite generally described as to stimulate innovation and industrial development. It is denoted as a strategy to present papers on conferences for feedback in order to enhance manuscripts for journal publication. This approach should be handled carefully to stress scientific quality and integrity. They should develop their own scientific identity. They recruited very good external professors and integrate emeriti professors to use their skills. They are well interlinked in international collaborations.

Scientific quality and productivity: **Grade: 3-4**

The publication productivity is well distributed and above international standards. The citation rates reach from good to very good along the researchers. Nevertheless, higher quality publications are rare taking into account the significance of their research and do not seem to be of high internal priority. External PhDs students are closely advised and integrated into the group.

Societal and industrial relevance and impact: **Grade: B**

Based on an appropriate strategy, the MSI has been very successful in the application and commercialization of their knowledge in the fields of acoustics and electronics and has a substantial influence on this topic in very distinct areas, including medical treatments as well as gas and petroleum flow measurement. Many researchers further contribute as peer-reviewers for different journals and in national and international acknowledged committees.

Recommendations to the research unit:

In general the strategy of the research area is well formulated. This strategy should be followed with a specific emphasis and extension on the following points, the progress should be monitored in a reasonable periodicity (6-12 month):

- MSI should strengthen basic research on new fields now with the integration of new people.
- Cooperation with Haukeland University Hospital sounds promising, but should be given more support in order to exploit the potential of this collaboration.

- More peer-reviewed and frequently cited proceedings should be addressed by all and not only a few of the associated researchers. This should be encouraged by appropriate measures.
- MSI should reduce relying on emeriti to the additional supervision of research students. The supervision of the PhD should be one of the main tasks of the active researchers.
- The option to gain higher synergy effects across the group should be evaluated.
- More advanced strategies to attract students already at bachelor level, e.g. by including them into research lab work.

4.5. University of Tromsø (UiT)

UiT The Arctic University of Norway is the northernmost university of the world. As the Arctic is of increasing global importance (climate change, the exploitation of Arctic resources, new shipping routes and environmental threats) dedicated research to Artic related areas is becoming more important. This trend is likely to increase even more in the coming decades; therefore a sophisticated R&D strategy concerning Artic subjects is thus beneficial and can help to achieve international excellence.

4.5.1. Department of Engineering and Safety

Evaluation Units:

Engineering and Safety

General comments on the department level:

The Department of Engineering and Safety is part of the Faculty of Science and Technology at the University of Tromsø – The Arctic University of Norway (UiT). The department was formed as the result of a merger of University College of Tromsø into the University. Thus, the department has only a very brief history to this moment. It has both study and research programs but Ph.D. students need to be enrolled in programs in other departments. The exact focus of the department is not well established as it aims at technology, safety, and human factor in the Arctic with emphasis on ship navigation and aviation but with little connection to traditional engineering, as the name of the department suggests. It further comprises a few diverse disciplines due to its course. However, it has a very young faculty and a very dynamic, enthusiastic, and ambitious but realistic leadership and this represents its main strength.

Follow up from previous evaluations:

The University of Tromsø was not part of the evaluation carried out by the Research Council in 2004.

Recommendations to the department/institution:

- The department should try to establish a clear focus for its activities.
- As maritime and aviation safety are very hot issues with ample funding especially from the EU, the department should seek to secure such projects apart from the undoubtedly necessary liaison with the local expanding industry.
- It should try to attract scientific staff with appropriate incentives but with clear targets.
- It should also try to seek advice and collaborate nationally and internationally.
- It should very soon develop a clear and aggressive research strategy including scientific output targets.

4.5.1.1. Engineering and Safety

Description of the research unit:

As the Department is small and diverse this is evaluated as one research group. In fact, research is conducted across teams that correspond to the various bachelor degrees. The group consists of 2 Professors, 10 Associate Professors, 8 Professors II, 2 Ph.D. Students, and one Research Advisor. The main focus of the group has been education and thus it can only recently be considered as a research group. There is no major research infrastructure at the moment but some smaller research equipment bought through funded research. Additionally, a remotely operated submarine and an airplane simulator for research are foreseen. All personnel are very young and many are recently graduated from Ph.D. programs in other universities.

Strategy, organization and research cooperation:

The goals of the group are very clear and ambitious. Projects are large and interdisciplinary but all research is applied and not basic, mainly because of the location and the focus on local industry. There is a clear strategy for the development of the group/department that ranges from incentives for attracting new members (such as infrastructure, promotion of internal and external collaborations, and formal cooperation with other universities). They currently cooperate with universities in Russia, Japan, Finland, Sweden, Canada, and in Norway. This is a very young group (and department) and it consists of people with diverse backgrounds. However, they are in the enviable position of having the chance to shape this unit in whichever way they wish and can. They appear to share a vision for research and education and a wish to make an impact to the local industry and society with the specific climate conditions in the Arctic. They also benefit from a capable and realistic leadership and in this sense they have shown to the evaluators a definite potential.

Scientific quality and productivity: **Grade: 2**

Scientifically the group is very diverse with a number of publications of which however very few count either due to the quality of the journals or due to the topic towards the research group activities. Productivity is still not sufficient but the group consists also of members who have just received their Ph.D.'s. On the other hand they demonstrated that they can cooperate with people from other universities and they also aspire to increase these collaborations and benefit from those.

Societal and industrial relevance and impact: **Grade: C**

Despite the lack of scientific volume, the group cooperates with a large set of (local mainly) industries and with some on a more formal basis. Their target is to produce results that assist the local society and industry (especially those that move into Tromsø) to adapt technology and operations to the hard arctic climate. They have already achieved a part of this goal through a series of applied projects underway or finished. Therefore, in this area the group has performed relatively well.

Recommendations to the research unit:

- The group should adopt a more systematic publication strategy and motivate all its members to increase scientific output.
- Publications should be focused on clear, narrow topics, which make publication easier.
- The group should try to exploit fully the results of the industrial projects it has undertaken.
- The group/department should continue to attract expertise in the form of adjunct professors (if permanent positions cannot be filled) that could help not only with educational/organizational issues but with research as well.
- The group should explore cooperation with other departments at the UiT.

4.6. Institute for Energy Technology IFE

The Institute for Energy Technology IFE is an international research institute for energy and nuclear technology with approximately 560 employees. IFE is organized in six sectors, thereof four are situated in Kjeller and two in Halden, including one research reactor in each location. Each sector is sub-divided into three to six departments with a typical staff size of 15 to 25 persons consisting of researchers, engineers, PhD-students, post docs and administrative personnel. IFE is organized in a line management with the director of the institute at top. The institute's strategy is based on 5-year plans with the current to end in 2015. As being typical for a research institute, the base funding is low and the majority of funds have to be acquired on a project basis with high direct or indirect contribution from industry.

4.6.1. Sector Energy and Environmental Technology

Evaluation Units:

Solar Energy

General comments on the sector level:

The objectives of the sector Energy and Environmental Technology is to contribute to effective energy consumption and to the development and introduction of new environmental friendly energy systems, processes and products in energy research to the Norwegian industry and the society as a whole. The sector is organized into four departments, including energy systems, environmental technology, solar energy and radwaste (radioactive waste) where funding distribution among them is fairly even as long as all departments show potential.

In principle the sector is well-structured with individual departments with relatively low interaction of different departments. They also report a good percentage of female employees, 24% and state that it is relatively easy to recruit female PhD students in the field.

Follow up from previous evaluations:

IFE was not part of the evaluation carried out by the Research Council in 2004.

Recommendations to the department/institution:

- Since there is specific knowledge in solar cell department and in energy systems to cover topics related to the use of solar energy in high latitudes, cooperation in this specific area seems reasonable and could lead to a unique international position.
- Further communicate the importance of renewable energy, especially solar energy, based on the drastically reduced cost within the technology. The institute should further promote this on a political level, highlighting the benefit of renewable energy for the society and economy.

4.6.1.1. Solar Energy

Description of the research unit:

The department was founded in 2008 and spun out of the Energy Systems department due to increased activity in the area. This included building a new large lab. The center of activity is the research lab, which is expensive to maintain. The main research topic of the department has been solar cell materials and technology. The department has a flat structure, with researchers and engineers directly reporting to the department head. The budget of the department is secured by project funding. The department has experienced a significant down-turn in the associated national and European industry in photovoltaics since 2011.

Strategy, organization and research cooperation:

The original strategy when the new lab was set up was based on the emerging photovoltaic industry in Norway and Europe and to work in the fields of silicon production technology, silicon material properties, solar cell materials, solar cell device design, solar cell processing technology, solar cell and module optics. The department head reacted on the recent down-turn by reducing staff and setting up new target topics, mainly within the field in areas with more national industrial demand, but partly outside the original field, i.e. moving to printed electronics. The department has strengthened its position by international research cooperation with leading institutions in Europe.

Scientific quality and productivity: Grade: 3-4

The department has a very good culture to produce high quality scientific contributions, based on a sound mixture of researchers and PhD students with excellent supervision. Innovations like the “publication week” and the encouragement to use the approach of cumulative PhD theses are very good measures to improve scientific productivity. IFE has a good-to-very good presence in international conferences and the principal researchers are well linked in the scientific community. On the other hand, there have been few outstanding contributions to this very competitive research field, so far. Overall the scientific quality and productivity is slightly above international average, but the trend for IFE’s solar energy department in view of scientific quality and productivity is critical due to the drastically reduced number of PhD students implied by the funding situation.

Societal and industrial relevance and impact: Grade: C

The institute is very well linked to the national industry with a strong focus on supporting their activities. The department has a very good output through very well qualified researchers. The funding structure has not allowed to sufficiently generate intellectual property to enable spin-off companies, but external companies have been supported successfully in their starting phase and there are a decent number of patents internally and externally which are partially granted.

Recommendations to the research unit:

- As planned, the group should concentrate on the material sector where it already started developing competences before. The excellent infrastructure should be used for

characterization purposes as manufacturing solar cells using current technologies is the most relevant measure in the field. Overall, material for silicon photovoltaics should be the topic where the department strives for an international forefront position.

- The activities in solar cell technology should be clearly focused since currently there are almost no industrial players in Norway and only a few in Europe, while the R&D competition in Europe is very strong.
- The group should use its good international network to further collaborate with international partners and may act as a scientific interface for the national industry.
- Investigation of specific topics of solar energy related to high latitudes should be strengthened.

4.7. Marine Technology Research Institute MARINTEK

General comments on the Institute level:

The Norwegian Marine Technology Research Institute, MARINTEK, develops and verifies technological solutions, business and operating concepts for the shipping, marine equipment, ocean energy and petroleum industries. MARINTEK's headquarters and laboratories are in Trondheim and shares space with NTNU (Department of Marine Technology), with subsidiaries in Houston, Texas and Rio de Janeiro, Brazil. MARINTEK is a non-profit company owned by SINTEF, the Norwegian Ship-owners Association, DNV GL and other minor shareholders. It has 197 employees. 34 % of the employees have a MSc degree, 28 % a PhD degree. 29 % are engineers/technical staff, primarily allocated to operations in laboratories with scientific employees from 24 nations and 19 % of those are female. Total turnover in 2013 was approx. 310 MNOK with a basic grant from the Research Council of Norway of approximately 15,3 MNOK. The remaining budget comes primarily from projects carried out directly from national and international industry partners (31 % of the turnover is international), and from projects co-funded by the Research Council of Norway or the EU framework programs.

MARINTEK's strategy is very well aligned with the National strategy for research. It plans to establish the Ocean Space Center with 5 research areas as adopted by the Government: Smart Maritime (Environmental friendly ships and safe operations), Deepwater (Marine operations and installations in ultra-deep waters; oil & gas and deep-sea mining), Arctic (Safe and sustainable operations in Northern waters), Renewables (Innovative ocean energy concepts incl. offshore wind), and Seafood (Robust & resilient concepts for food from the ocean). MARINTEK is confident in the success of the endeavor and has invested a large amount of resources to this end.

MARINTEK encourages its personnel to increase scientific output and dissemination of research results and has established internal measures to this end (such as internal prizes for publication in high rated journals). In fact, it has improved quality and output of papers. It furthers seeks international recruitment of employees. MARINTEK makes use of members of the scientific staff at NTNU as advisors, and they also have cooperation with NTNU on project level. Despite its contracted research, it has the policy of not keeping IP so as not to compete with its contractors. It claims that its basic research is performed independently from its shareholders' interests although these normally do not come into conflict with one another. However, basic research results may not be as visible and may be on a different level concerning impact in industry and perception by society compared to contracted research whose results find direct application in industry.

Follow up from previous evaluations:

MARINTEK was not part of the evaluation carried out by the Research Council in 2004.

Recommendations to the Marine Technology Research Institute MARINTEK:

- MARINTEK should keep its cooperation with NTNU, which has proved successful to date, but is also encouraged to seek a more open and independent identity so as to establish an even more autonomous identity in the international community, which will also increase its impact in the international industry as well.
- Despite the fact that it is one of the leaders in the field nationally, it is definitely advised to promote more actively both basic research and scientific excellence and to take substantial targeted measures to claim a more established position in the international scientific community.
- It is finally encouraged to increase and promote multidisciplinary research.

4.7.1. Department Marine Transport Systems

Evaluation Units

Logistics and Operations Research

Recommendations to the department:

- Since there is a substantial amount of interaction between the departments and the evaluated groups, general recommendation are given in the section above.

4.7.1.1. Logistics and Operations Research

Description of the research unit:

The research group consists of 6 full-time scientific employees, 2 part time employees working on their post-doc, 1 scientific advisor who has a professor position at NTNU, and 1 software engineer. Among these, there are 2 women and 2 with foreign background. The group has a relatively low average age (< 40), where 2/3 are young researchers at around 30 which are being mentored by the 1/3 senior researchers. Almost every member of the group has extensive knowledge of Operations Research and Logistics. They have backgrounds from NTNU, Norwegian School of Economics and Business Administration (NHH), Molde University College and Humboldt- University. The main focus of the research activity has been in the fields of strategic fleet analysis, ship routing and scheduling, and ship design and evaluation.

Strategy, organization and research cooperation:

Due to the nature of the area, the group has adopted an interdisciplinary research attitude and will also participate in the forthcoming Ocean Space Center in the thematic areas of Smart Maritime, Offshore Wind and Seafood. The group has a clear research strategy for topics in shipping, oil and gas, and ocean energy and has focused on relevant specific programs nationally and internationally (RCN, EU, etc.) with the aim of increasing research competence and establishing models for further exploitation. It also aims at innovation projects for research development but also industrial projects for application of results and for feedback to research. It keeps close cooperation with SINTEF ICT and NTNU (Institute of Industrial Economy and Technology Management and Institute for Marine Technology). The

group cooperates very closely with NTNU even for recruitment purposes. It uses one established professor as scientific advisor and this is very useful. It does not have a physical laboratory and although it covers a broad range of disciplines it still lacks a substantial amount of human resources for each field.

Scientific quality and productivity: Grade: 3-4

The group has benefited from the Gemini Center it maintains with NTNU, which represents a national center of gravity for research and education within operations research in maritime logistics, and is internationally recognized as one of the leading communities within the field and this has led to established collaboration with several international research communities. This structure also allows the research group to boast good scientific output. This, however, is not balanced, as the main contributor is the scientific advisor from NTNU while the rest have barely sufficient scientific productivity. Nevertheless, they are a young with a holistic vision for the future and are apparently a dynamic group with enthusiastic leadership. Thus, they have very good chances of developing successfully.

Societal and industrial relevance and impact: Grade: B

The group works in an area that is of strategic priority for shipping companies as they seek to operate in the most efficient manner, both by actively selecting tonnage that has attractive "green" designs and by optimizing speed and operating patterns. It has executed and continues to work on several projects with high industrial impact over the last five years in fields such as offshore wind energy optimization, fleet renewal, maritime fleet size and mix, logistics chains, risk management, etc. The knowledge developed is disseminated through various activities, including industry seminars and close co-operation with ship-owners Associations.

Recommendations to the research unit:

- It is encouraged to increase research based on full-scale data from vessels, as identified by the group, as it is a big scientific opportunity as well as taking a systems approach.
- It should promote stronger collaboration with other research groups so as to benefit from the osmosis of scientific knowledge and methods.
- As the group is very young, it is encouraged to promote a more aggressive publication strategy in terms of quantity and quality.
- It is encouraged to recruit more scientists from a wider spectrum of disciplines, universities, and countries to increase its multidisciplinary and international character.
- It is encouraged that they establish their own scientific identity apart from NTNU.
- It is encouraged to seek a wider range of industrial projects outside their current expertise to further increase its impact.

4.7.2. Department Energy Systems and Technical Operation

Evaluation Units:
Energy Systems

Recommendations to the department:

- Since there is a substantial amount of interaction between the departments and the evaluated groups, general recommendation are given in part two sections above.

4.7.2.1. Energy Systems

Description of the research unit:
The group consists of 8 full-time scientific employees including 2 PhD-students, 2 scientific advisors who have an assistant professor position at NTNU, and 2 engineers. 2 of the scientific staff have a foreign background. The average age of the group is medium (mid-40s), about 1/3 are young researchers at around 30 who are being mentored by the senior researchers. The competences of the group extend from combustion technology and thermodynamics to chemistry. The group focuses on the combination of experimental laboratory work, mathematical models, field studies and case studies for maritime energy system applications.

Strategy, organization and research cooperation:
Main research disciplines of the group range from experimental laboratory setups to exhaust gas emissions, energy efficiency, and hybrid power systems, but its strategy also aims at deep sea and short sea shipping, and offshores. Although it has an extensive project portfolio from basic research projects (through RCN and the EU) to innovation and industrial projects, its focus is not entirely clear or is too diverse while research targets are selected without specific strategy. The group has outdated laboratory equipment and little international collaboration. It does keep a connection with NTNU and its collaboration range from education to sharing infrastructure, but scientifically this connection remains weak. It has overall goals of "greening" the Norwegian maritime cluster but it does not lay out a very precise strategy despite the fact that its contribution to this end has been so far very good, and this is recognized by the respective industry. Finally, collaboration with other groups within MARINTEK is not a priority.

Scientific quality and productivity: **Grade: 3-4**
The group has a strong theoretical background but apart from a few individuals with a more extensive scientific work, overall publication output is only above average. However, the group is active among others in an area (exhaust gas emissions) where substantial scientific output is possible as it is a relatively new area and its involvement there is established and extensive. Many of the projects it has undertaken could have led to significant publications, had this been pursued more systematically or had a clear publication strategy been in place.

Societal and industrial relevance and impact: Grade: A-B

It is a strategic priority for shipping companies to operate in the most efficient manner possible, both by actively selecting tonnage that has attractive “green” designs and by optimizing speed and operating patterns. In this area, the group has been in the forefront of policy shaping and has been assisting the industry realize the benefits and adopt new strategies. The research group aims at creating further value for the industry by developing knowledge, expertise, models and applications that will increase operational efficiency of vessels, with particular focus on fuel efficiency and emission reduction.

Recommendations to the research unit:

- The group should adopt a more systematic publication strategy and motivate all its members to increase scientific output.
- Publications should be focused on clear, narrow topics, which make publication easier.
- The group should try to exploit fully the results of the many research projects it undertakes.
- The group should seek to benefit from collaboration with other groups within the company.
- It should try to benefit as much as possible from its involvement in the Ocean Space Center.

4.8. SINTEF

4.8.1. SINTEF Fisheries and Aquaculture

Evaluation Units:

Fishing Gear Technology
Process Technology
Marine ICT

SINTEF Fisheries and Aquaculture has the scientific ambition to contribute to developing technology as a competitive advantage to the fisheries and aquaculture industry. SINTEF work very closely with the industry and associated PhD-students are mainly working on industrial oriented research challenges. PhD students are mainly employed at the universities, with the universities having and taking the main responsibility to ensuring the independence and give them the ability to leadership training. The institute has a relatively good balance between short-term and long-term projects. The international activities consist primarily of revenue related to the laboratory in Hirtshals and EU projects. The major part of the income (approx. 90 %) comes from contract research in open competition with other research environments, where half of these projects are funded by the industry. The last 10% comes from basic grants from the Research Council of Norway. The basic grant is strategically very important for the institute and gives a certain freedom to implement suitable strategies and investments for future research at SINTEF. SINTEF Fisheries and Aquaculture, one out of eight research institutes in SINTEF, is organized in five research departments:

1) *Fisheries Technology*: vessel and equipment research, safety in the fishing fleet, marine ICT;
2) *Aquaculture Technology*: aquaculture structures, management and operation, farming intelligence and systems;
3) *Process Technology*: process technology, automation, processing of marine raw materials to consumer products, feed and ingredients;
4) *Marine Resources Technology*: Modelling of marine systems, new species in aquaculture, macro-algae, aquaculture and start feeding of fish;
5) *Research based consulting*: National and international advisory services for companies and public administration.

Follow up from previous evaluations:

SINTEF was not part of the evaluation carried out by the Research Council in 2004.

Recommendations to the departments:

- The strategic plan for SINTEF Fisheries and Aquaculture (2014-2017) is based upon serving the fisheries and aquaculture industry. SINTEF Fisheries and Aquaculture should contribute and make significant difference to the development of a sustainable (environmental, economic and social) fisheries and aquaculture industry in Norway and global

- The role of SINTEF is to support the national Norwegian industry and the society at large. This cannot be achieved by exclusively carrying out research projects for industry. The academic development must be cultivated. This is done through basic research performed in contact and co-operation with the international academic community, publishing in internationally recognized journals.

4.8.1.1. Fishing Gear Technology

Description of the research unit:

The research group is geographically split at three sites: the main office in Trondheim, Tromsø and Hirtshals, Denmark, where a main activity is the operation of the institute's large scale flume tank. The research group as such focuses on specific and long-term R&D projects. The group consists of 9 researchers. The human resources in terms of competence and level are very good, and this is a result of strategic recruitment. A large portion of the projects are industrial and of an applied nature, with few pure research projects.

Strategy, organization and research cooperation:

The group works closely together with the research groups in Marine ICT (e.g., simulation of trawl and seine) and Process Technology. The research coheres very closely with trends and developments, because it is largely funded by industry oriented programs and co-funded by industry. For the same reasons, and a focus on also basic research being founded in the strategy, the link between basic and applied research is also very close. Some of the methodologies developed for fishing gear selectivity are also utilized in other sectors, particularly in work related to challenges in the aquaculture industry.

Scientific quality and productivity: **Grade: 3**

For such a small group, they have a good number of publications, including papers in refereed journals, and an internationally acknowledged expertise. A specific goal is to increase the publication rate by 0.1 pr. researcher pr. year. This is done by stimulating the researchers e.g. by specific use of certain forms of basic funding.

Societal and industrial relevance and impact: **Grade: B**

The research area has a high relevance and is of strategic importance for Norway. The group has a large international exposure and a strong impact. It is strong both academically and scientifically, dealing with problems of high relevance for industry as well as scientific society. In this combination of disciplines, the research is well integrated with Marine ICT, industry and international cooperation partners

Recommendations to the research unit:

- The group should develop a coherent strategy with identifiable short and long term goals, which involves relevant partners inside and outside the group.
- We recommend the group to continue in these directions to strengthen even more, and put more effort into improving scientific productivity.

- The group has established a world-class competence; it should actively seek new areas of research, where their expertise can be used.

4.8.1.2. Process Technology

Description of the research unit:

The group is divided into the following three focus areas, all of them with strong focus on technology development, with a research manager and different qualifications profile: 1) Raw material and processing: Chemistry, food chemistry, biotechnology, food technology, thermodynamics, catch handling on board, fish and food quality, fish welfare and stress connected to slaughtering process, measuring techniques, water quality, refrigeration, salting and salt reduction; 2) Automation and efficient production: Cybernetics, robotics, machine technology, process technology, industrial and product design, food technology, environment and sustainability; 3) Bioprocessing: Biotechnology, chemistry, food chemistry, chemical engineering, analytical techniques, food technology, agriculture engineering, traceability and logistics.

Strategy, organization and research cooperation:

The researchers in the group are organizationally divided between the three areas abovementioned, but working in projects that are cut across the focus areas so that projects are interdisciplinary organized and conducted. The distribution of scientific publications among the group's researchers has been 0.7 per researcher per year. One patent together with an industrial partner was approved in 2012. The group has a strategy to achieve collaboration across disciplines and with other research institutes, universities and industry both nationally and internationally. Having scientists from different nationalities in the group, the opportunity for international cooperation is very good. Very high hourly rates are an obstacle for participation in international projects.

Scientific quality and productivity: **Grade: 3-4**

The group has a very good international publication record with a good productivity of research with relevance to international research development. The group follows the institute's strategy for publication and dissemination of research results. The institute's goal is 1.0 publication per researcher per year. To achieve this it is envisaged incentives that the whole group will benefit by allowing allocation of basic funding for the groups. This is based on a key calculated from the number of publications in reputable journals with peer-reviewed articles the group has delivered the previous year. This will stimulate to increase publication rate per researcher, as well as popular scientific articles. Scientific productivity is limited due to the confidential nature of some industrial projects.

Societal and industrial relevance and impact: **Grade: B**

Most of the projects have one or more items of technological development for more efficient and automated production, more sustainable production, food quality and safety, healthy foods such as reduction of salinity and reduction of oxidation of marine oils, animal welfare and HSE. The group has contributed to industrial partners which have lost market areas to

develop new business area within aquaculture. Generally, the strategy is to help partners through their projects to develop unique solutions for the users, not to create as many patents as possible. They develop knowledge through research projects for the industry.

Recommendations to the research unit:

- The group should seek additional funding (e.g. EU DG-MARE) to grow since it has the potential to be an internationally leading group in technology development.
- The group should increase the share of basic research.

4.8.1.3. Marine ICT

Description of the research unit:

The group consists of people of two organizational units: Marine ICT and Aquaculture Structures. In general, the group's research is focused on developing knowledge of marine structures and operations, with interest on aquaculture structures, fishing tools and fishing operations. The scientific disciplines covered by the group are hydrodynamics, fluid mechanics, structural mechanics, oceanography, cybernetics, and software development. The scientific tools in focus are model experiments, full scale testing, and numerical modelling. The group does not have any laboratory facility, but they have quite an extensive activity on modelling experiments. All the research projects conducted by the group are applied research projects.

Strategy, organization and research cooperation:

The research strategy of the group is formed as a combination of inclusive group processes and project opportunities that arise during the year. The research strategy of the group can be summarized into developing knowledge and solutions that will contribute towards a sustainable fishing and aquaculture industry. The aquaculture branch of the research group is mostly focusing on the salmon-farming industry in Norway. The strategy of the group is also motivated by new industry trends, like the increased focus on aquaculture production in closed containments. The fisheries technology branch of the research group is focusing on improving marine operations and fishing equipment. The main strategy is to develop software and almost all the research projects conducted by the group are applied research with low basic scientific aspects and therefore relevance and productivity of basic research is modest.

Scientific quality and productivity: Grade: 2

The strategy of the group is to plan for publications in peer-reviewed journals or conferences for dissemination of open results from research projects whenever possible. For industry projects, the customer is asked whether results can be used for publication. Results which are believed to be of interest for the fisheries- and aquaculture industry, obtained from open research projects are sought to be presented in industrial fairs, newspapers or trade magazines. The rate and the level of scientific publications are low. Scientific publications are very limited (as an average for the group, but there are big differences within the group).

Societal and industrial relevance and impact: Grade: C

The research group has developed the time domain simulation framework FhSim, which forms the basis for ongoing research, analyses and industrial applications. Example applications are training simulators within offshore, aquaculture and fisheries, real-time supervision of marine systems and tools for design of aquaculture systems, fishing tools and ship energy systems. Systems for acquisition, sharing and analysis of operational data are providing a basis for new applications, such as decision support and better design of ships.

Recommendations to the research unit:

- Publication policy should be significantly improved and the international profile of the group should be raised;
- It should increase its cooperation with the other international groups and intensify its work to get funding for more doctoral graduate students.
- The unit should seek to establish an identity and strategy for future course.

5. Mandate for the review

5.1. Terms of reference

Introduction

The Ministry of Education and Research has assigned the task of performing subject-specific evaluations to the Research Council of Norway (RCN). The Division of Science has decided to evaluate basic research within engineering science in universities, university colleges and relevant research institutes during 2014.

The previous evaluation of the research in engineering science was carried out in 2004.

The objective of the evaluation

The objective of this evaluation is to review the overall state of basic and long term research in engineering science in Norwegian universities, university colleges and relevant contract research institutes. The evaluation shall provide knowledge and recommendations for future development of basic research within engineering science in Norway, and lay the foundation for determining future priorities, including funding priorities, within and between individual fields of research.

For the institutions that are evaluated, the evaluation will provide knowledge, advice and recommendations that can be used to enhance their own research standards. For the RCN the evaluation will contribute to an improved knowledge base that is used when giving advice on research policies to the Norwegian Government.

Specifically, the evaluation is expected to:

- Provide a critical review of the strengths and weaknesses of basic and long term research in engineering science in Norway, both nationally as well as at the level of departments and individual research groups. The scientific quality shall be reviewed in an international context.
- Identify research groups that have achieved a high international level in their research or have potential to reach such a level.
- Identify areas of research that need to be strengthened in order to ensure that Norway in the future will have the necessary competence in areas of national importance.
- Discuss to what extent the research meets the demand of interdisciplinary research and future societal challenges.
- Assess the situation with regard to recruitment of PhD candidates in engineering science.
- Assess to what degree the previous evaluation have been used by the institutions in their strategic planning.

Organization and methods

The evaluation will be carried out by an international Evaluation Committee consisting of three sub-panels. Each panel will carry out the evaluation in their field of expertise.

- Energy and process technology
- Product, Production, Project management, Marine systems and Renewable energy
- Civil Engineering and Marine structures

The panels will base their evaluation on self-assessments provided by the departments/research groups, a bibliometric analysis provided by the Research Council, as well as on interviews and presentations given in meetings with the involved departments/research groups. The self-assessments from the institutions will include factual information about the organisation and resources, future plans, CVs, and publication lists of their scientific staff.

The panels are requested to present its findings in written reports. Preliminary reports will be sent to the departments/research groups included in the evaluation for a assessment of the factual information. The Committee's final reports will be submitted to the Board of the Division for Science for final approval.

The principal evaluation committee will consist of the leader and one member from each sub-panel.

Tasks of the evaluation sub-panels

The panels are requested to

- Evaluate research activities with respect to scientific quality, national and international collaboration. The evaluation shall focus on research that are/can be published in peer-reviewed publications and conferences. Contract research with restricted public access to the results is not included in this evaluation.
- Evaluate the relevance and impact of the evaluated research activities.
- Evaluate how the research is organized and managed.
- Submit a report with specific recommendations for the future development of research within engineering science, including means of improvement when required.

Aspects to be addressed in the sub-panel reports:

1. National aspects

- Strengths and weaknesses of Norwegian Engineering Science research in an international context
- Impact and relevance of the evaluated research with regard to the future needs of national and international business- and public sectors
- The impact of national excellence centres (SFF, SFI, FME, NCE, ..) on scientific quality and societal impact and relevance.

- Research cooperation nationally and internationally
- General resource situation regarding funding and infrastructure
- Training, recruitment, gender balance and mobility
- Any other important aspects for consideration

2. Institutions/departments

- Does the institution/department have an overall research strategy which feeds into the individual research group strategy?
- Is research leadership being exercised in an appropriate way?
- Is there sufficient collaboration between research groups within the institution/department?
- Are there satisfactory policies in place guiding the recruitment and handling of employees?
- Are the efforts to increase gender balance in scientific positions satisfactory?
- In which way have the previous evaluation (2004), national research policies and White Papers been used by the institution/department in its own strategic planning?

3. Research groups

Strategy, organization and research cooperation

- Has the research group developed a satisfactory strategy with plans for its research, and is it implemented?
- Is the size and organization of the research group reasonable?
- Is recruitment, including measures to address gender balance, handled satisfactory?
- Is there sufficient contact and co-operation with other research groups nationally, both within universities, university colleges and research institutes?
- Does the research group take active part in interdisciplinary/multidisciplinary research activities?
- Is the international network e. g. contact with leading international research groups, number of international guest researchers, and number of joint publications with international colleagues, satisfactory?
- Do they take active part in internationally funded projects, international professional committees, work on standardization and other professional activities?
- How is the long term viability of the staff and facilities evaluated in view of future plans and ideas, staff age, research profile, new impulses through recruitment of researchers?

Scientific quality and productivity: To be rated on a scale 1 - 5

- Do the research groups maintain a high scientific quality judged by the significance of contribution to their field, prominence of the leader and team members, scientific impact of their research?
- Is the productivity, e.g. number of scientific and professional publications and Ph. D. thesis awarded, reasonable in terms of the resources available?

- Do they show ability to work effectively with professionals from other disciplines, and to apply their knowledge to solve multifaceted problems?

Relevance and impact: To be rated on a scale A - E

- Do the research have a high relevance judged by impact on society, value added to professional practice, and recognition by industry and public sector?
- Does the research group have contracts and joint projects with business and public sector, are they awarded patents, or do they in other ways contribute to innovation?
- Does the research group contribute to the building of intellectual capital in industry and public sector?
- Do they play an active role in dissemination of their own research and new international developments in their field to industry and public sector?
- Do they play an active role in creating and establishing new industrial activity?

Tasks of the principal evaluation committee (Joint Committee)

The committee is requested to compile a summary report based on the assessments and recommendations from the three sub-panels. This report should offer an overall assessment of the state of the research involved. The report should also offer a set of overall recommendations concerning the future development of this research.

The committee is requested to:

- Summarize the overall scientific quality and relevance of the research within engineering science. Identify which research areas have a particularly strong scientific position in Norway, in a national and international context, and which are particularly weak?
- Summarize general assessments related to structural issues
- Summarize how the research institutions have followed up former evaluations
- Are there any other important aspects of research within engineering science that ought to be given special consideration on a national or international level?

The committee's conclusions should lead to a set of recommendations for the future development of research in engineering sciences in Norway.

Tentative outline of the joint report

- Executive summary
- Research areas – major general findings
    - Scientific quality
    - Impact and relevance
- Structural issues
- Follow up of former evaluations
- Other aspects of importance
- Recommendations

5.2. Assessment Criteria

Assessment of Research Groups

Three main areas of performance is highlighted for the research groups in the mandate for Evaluation of Engineering Science, and the mandate describes what is covered for each of these areas:

- **Scientific quality and productivity**
- **Relevance and impact**
- **Strategy, organization and research cooperation**

For two of these criteria an assessment should be made using a five point scale.

Scientific quality and productivity:

5 – excellent
4 - very good
3 – good
2 – fair
1 – weak

Relevance and impact:

A – very high relevance and impact
B – high relevance and impact
C– good relevance and impact
D – low relevance and impact
E – very low relevance and impact

Scientific quality and productivity

For "scientific quality and productivity" the following three points appear in the mandate:

- Do the research groups maintain a high scientific quality judged by the significance of contribution to their field, prominence of the leader and team members, scientific impact of their research?
- Is the productivity, e.g. number of scientific and professional publications and Ph. D. thesis awarded, reasonable in terms of the resources available?
- Do they show ability to work effectively with professionals from other disciplines, and to apply their knowledge to solve multifaceted problems?

For this item the following should be used as a basis for the rating. The rating **3 = good** means that the group performs to the standard normally to be expected from a research group in its field.

Excellent

International front position, undertaking original research and publishing in the best international journals and presenting research at recognised international conferences with peer review. High productivity. Very positive overall impression of the research group.

Very good

High degree of originality, a publication profile with a high degree of international publications in good journals and at recognised international conferences. High productivity and very relevant to the field internationally. Very positive overall impression of the research group.

Good

Contribute to international and national research with good quality research of relevance to international research development. Acceptable productivity. Positive overall impression of the research group. The group performs to the standard normally to be expected from a group in its field.

Fair

The quality of research is acceptable, but international profile is modest. Much routine work. Relevance and productivity of research is modest. No original contributions to the field of research. Overall impression is positive but with a distinct degree of scepticism from the evaluators.

Weak

Research quality is below good standards and the publication profile is meagre. Only occasional international publication or presentations. No original research and little relevance to problem solving. Not an overall positive impression by evaluators.

Relevance and impact

For “relevance and impact” the following five points appear in the mandate:

- Do the research have a high relevance judged by impact on society, value added to professional practice, and recognition by industry and public sector?
- Does the research group have contracts and joint projects with business and public sector, are they awarded patents, or do they in other ways contribute to innovation?
- Does the research group contribute to the building of intellectual capital in industry and public sector?
- Do they play an active role in dissemination of their own research and new international developments in their field to industry and public sector?
- Do they play an active role in creating and establishing new industrial activity?

The panel should give a rating of the research group based on how they evaluate the performance of the group related to these points. The rating **C = good relevance and impact** means that the group performs to the standard normally to be expected from a research group in its field.

A = very high and **B= high** means that the group is above standards and **D = low** and **E = very low** the group is below the standard to be expected for a group in its field.

6. Research groups included in the evaluation

Institution	Faculty/ Business area	Institute/ Department	Project group to be evaluated	Panel 1	Panel 2	Panel 3
NTNU	Faculty of Engineering Science and Technology (IVT)	Energy and Process Engineering	Thermal Energy	x		
			Industrial Process Technology	x		
			Fluids Engineering	x		
			Energy and Indoor Environment	x		
			Industrial Ecology		x	
		Civil and Transport Engineering	Building and Construction			x
			Geotechnics			x
			Marine Civil Engineering			x
			Road, Transport and Geomatics			x
		Structural Engineering	Concrete			x
			SIMLab			x
			Structural Mechanics			x
			Biomechanics			x
		Marine Technology	Marine Technology			x
			Marine Systems		x	
		Engineering Design and Materials	Materials			x
			Design, Analysis and Manufacturing		x	
		Production and Quality Engineering	Production Systems		x	
			Production Management		x	
			Project and Quality Management		x	
			Reliability, Availability, Maintainability and Safety (RAMS)		x	
		Hydraulic and Environmental Engineering	Water and Wastewater Engineering			x
			Hydraulic Engineering			x
		Petroleum Engineering and Applied Geophysics	Petroleum Technology and Applied Geophysics	x		
		Product Design	Product Design		x	

	Faculty of Natural Sciences and Technology (NT)	Materials Science and Engineering	Physical Metallurgy	x		
			Process Metallurgy	x		
	Faculty of Information Technology, Mathematics and Electrical Engineering (IME)	Electric Power Engineering	Electric Energy Conversion	x		
			Electric Power Technology	x		
			Electric Power Systems	x		
NMBU	Faculty of Environ-mental Sciences and Technology	Mathematical sciences and Technology	Water and Environmental Technology			x
UiA	Faculty of Engineering and Science	Engineering Sciences	Mechatronics		x	
			Renewable Energy		x	
			Civil engineering and offshore Construction			x
UiB	Faculty of Mathematics and Natural Sciences	Physics and Technology	Petroleum and Process Technology	x		
			Measurement Science and Instrumentation		x	
UiS	Faculty of Science and Technology	Department of Petroleum Engineering	Drilling and Well Technology	x		
			Natural Gas Technology			
			Reservoir Technology			
		Department of Mechanical and Structural Engineering and Materials Science	Mechanical Engineering and Materials Science			x
			Offshore-technology			
			Civil Structural Engineering			
UiT	Faculty of Science and Technology	Engineering and Safety	Engineering and Safety		x	
Telemark University College	Faculty of Technology		Process, Energy and Automation Engineering	x		
Østfold University College	Faculty of Engineering		Engineering Sciences			x
Gjøvik University College	Faculty of Technology, Economy and Management		Sustainable Manufacturing		x	
IFE		Energy and Environmental Technology	Solar energy		x	
NGI		Offshore energy	Computational Geomechanics			x
		Natural Hazards	Geosurveys			x
		Environmental Engineering	Water and Resources			x

IRIS		IRIS Energy	Drilling and Well modelling	x		
			Enhanced Oil Recovery	x		
			Reservoir	x		
MARINTEK		Offshore Hydrodynamics	Hydrodynamic Modelling			x
			Structural Engineering			x
		Ship Technology	Seakeeping and Control			x
		Maritime Transport Systems	Logistics and operations research		x	
		Energy systems and Technical Operation	Energy Systems		x	
SINTEF Building and infrastructure			Building physics Group			x
			Concrete Group			x
SINTEF Materials and Chemistry		Materials and Nanotechnology	Material- and Structural Mechanics			x
SINTEF Energy Research			Bioenergy	x		
			Combustion	x		
			Power conversion and transmission	x		
			Flow phenomena	x		
SINTEF Fisheries and Aquaculture			Fishing gear technology		x	
			Process Technology		x	
			Marine ICT		x	

7. Schedule for panel meetings

PANEL 2						
Date	start time	end time	time	Activity	Group no	Location / group name
	Sunday 23. nov					Trondheim, Rica Nidelven Hotel
Sunday	18:00	20:00	02:00	Introductory panel meeting		
	Monday 24. nov					Trondheim, Rica Nidelven Hotel
Monday	09:00	10:00	01:00	Preparatory panel meeting		
	10:00	10:15	00:15	Interview department	P2-11	MARINTEK
	10:15	10:45	00:30	Interview group	P2-11a	Logistics and Operations Research
	10:45	11:00	00:15	Panel discussion		
	11:00	11:30	00:30	Interview group	P2-11b	Energy Systems
	11:30	11:45	00:15	Panel discussion		
	11:45	12:00	00:15	Break		
	12:00	12:15	00:15	Interview department	P2-2	NTNU IVT Marine Technology
	12:15	12:45	00:30	Interview group	P2-2a	Marine Systems
	12:45	13:00	00:15	Panel discussion		
	13:00	14:00	01:00	Lunch		
	14:00	14:15	00:15	Interview department	P2-12	SINTEF Fisheries and Aquaculture
	14:15	14:45	00:30	Interview group	P2-12a	Fishing Gear Technology
	14:45	15:00	00:15	Panel discussion		
	15:00	15:30	00:30	Interview group	P2-12b	Process Technology
	15:30	15:45	00:15	Panel discussion		
	15:45	16:00	00:15	Break		
	16:00	16:30	00:30	Interview group	P2-12c	Marine ICT
	16:30	16:45	00:15	Panel discussion		
	16:45	17:00	00:15	Interview department	P2-5	NTNU IVT Product Design
	17:00	17:30	00:30	Interview group	P2-5a	Product Design
	17:30	18:30	01:00	Panel discussion - drafting of report		
	Tuesday 25. nov					Trondheim, Rica Nidelven Hotel
Tuesday	09:00	09:30	00:30	Preparatory panel meeting		
	09:30	09:45	00:15	Interview department	P2-1	NTNU IVT Energy and Process Engineering
	09:45	10:15	00:30	Interview group	P2-1a	Industrial Ecology
	10:15	10:30	00:15	Panel discussion		
	10:30	10:45	00:15	Interview department	P2-3	NTNU IVT Engineering Design and Materials
	10:45	11:15	00:30	Interview group	P2-3a	Design, Analysis and Manufacturing
	11:15	11:30	00:15	Panel discussion		
	11:30	12:30	01:00	Lunch		
	12:30	12:45	00:15	Interview department	P2-4	NTNU IVT Production and Quality Engineering
	12:45	13:15	00:30	Interview group	P2-4a	Production Systems
	13:15	13:30	00:15	Panel discussion		
	13:30	14:00	00:30	Interview group	P2-4b	Production Management
	14:00	14:15	00:15	Panel discussion		
	14:15	14:30	00:15	Break		
	14:30	15:00	00:30	Interview group	P2-4c	Project and Quality Management
	15:00	15:15	00:15	Panel discussion		
	15:15	15:45	00:30	Interview group	P2-4d	RAMS
	15:45	16:45	01:00	Panel discussion - drafting of report		
	18:15			Departure from hotel		
	19:30			Travel to Oslo		Gardermoen, Radisson Blu Hotel

Wednesday 26. nov						Gardermoen, Radisson Blu Hotel
Wednesd	09:00	09:30	00:30	Preparatory panel meeting		
	09:30	09:45	00:15	Interview department	P2-9	Gjøvik University College
	09:45	10:15	00:30	Interview group	P2-9a	Sustainable Manufacturing
	10:15	10:30	00:15	Panel discussion		
	10:30	10:45	00:15	Interview department	P2-7	University of Bergen
	10:45	11:15	00:30	Interview group	P2-7a	Measurement Science and Instrumentation
	11:15	11:30	00:15	Panel discussion		
	11:30	11:45	00:15	Break		
	11:45	12:00	00:15	Interview department	P2-8	University of Tromsø
	12:00	12:30	00:30	Interview group	P2-8a	Engineering and Safety
	12:30	13:00	00:30	Panel discussion		
	13:00	14:00	01:00	Lunch		
	14:00	14:15	00:15	Interview department	P2-6	University of Agder
	14:15	14:45	00:30	Interview group	P2-6a	Mechatronics
	14:45	15:00	00:15	Panel discussion		
	15:00	15:30	00:30	Interview group	P2-6b	Renewable Energy
	15:30	15:45	00:15	Panel discussion		
	15:45	16:00	00:15	Break		
	16:00	16:15	00:15	Interview department	P2-10	IFE
	16:15	16:45	00:30	Interview group	P2-10a	Solar Energy
	16:45	18:15	01:30	Panel discussion - drafting of report		
Thursday 27. nov						Gardermoen, Radisson Blu Hotel
Thursday	09:00	13:00	04:00	Panel discussion - drafting of report		
	13:00	14:00	01:00	Lunch		
	14:00	17:00	03:00	Panel discussion - drafting of report		
Friday 28. nov						Gardermoen, Radisson Blu Hotel
Friday	09:00	13:00	04:00	Panel discussion - drafting of report		
	13:00	14:00	01:00	Lunch		
	14:00	15:00	01:00	Panel discussion - drafting of report		
	15:00	16:00	01:00	Summary panel meeting		

8. Curriculum vitae for the Panel members

Dr. Ralf Preu

Ralf Preu is director of division “PV Production Technology and Quality Assurance“ at the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, Germany, the largest European research institution in this field with more than 1200 employees. He obtained a diploma in physics in 1996 from the University of Freiburg, Germany. He also holds a degree in econophysics and a PhD in electric engineering from University of Hagen, Germany. His field of research includes innovative approaches and technologies for the fabrication of crystalline silicon solar cells. Dr. Preu joined Fraunhofer ISE in 1993 and has worked in various fields of photovoltaics, such as system monitoring, cell and module technology, characterization and simulation. In 2002, he became head of the group solar cell fabrication technology and since 2007 he is head of the division “PV Production Technology and Quality Assurance”. From 2004 to 2006, Dr. Preu was managing director of the Fraunhofer ISE Spin-Off company PSE mbH. He is author and co-author of more than 200 scientific publications, member of several scientific committees in his field and holds more than 15 patents. He and his team were repeatedly awarded internationally reknown prizes for his contributions to the PV community, including the Innovation Award Laser Technology 2014 for the successful industrial transfer of a laser based contacting process to increase the efficiency of solar cells. Since 2009 Dr. Preu holds lectures on Photovoltaic Technology at the University of Freiburg, with the Renewable Energy Management Master Program.

Professor Margareta Norell Bergendahl

Margareta Norell Bergendahl is professor in Integrated Product Development, IPD (since 1996), in the School of Industrial Engineering and Management, and Vice President at KTH since 2010. She has a background in Mechanical Engineering, a Master degree in pedagogics, PhD in Machine Elements. During her career she has held positions as industrial product develop manager, teacher and researcher/advisor in several environments (including one year at NTNU). Her research interest relates to work procedures and methodologies for efficient and innovative co-operation and leadership in industrial product development processes, and she has frequently acted as reviewer for journals, applications and conferences. The current main responsibility for prof Norell Bergendahl as Vice president is to develop strategic collaboration with industry and society, and to increase the mobility between the university and selected partners. She worked 1999 - 2007 as selected pro-rector at KTH. 2003-2004 she was appointed by the Swedish Government as main investigator for the investigation on the overall Swedish Research Education. She has been an active member of International Design Society (DS) and contributed in the forming of the DS, during the years having roles in the Advisory Board and the Management Board within DS. She is a member of IVA Royal

Swedish Academy of Engineering Sciences since 1999, and member of the IVA Board from 2012.

Associate Professor Dimitrios V. Lyridis

Dimitrios V. Lyridis is an Associate Professor in Marine Systems Management in the area of Maritime Transport of the School of Naval Architecture and Marine Engineering (NA&ME) at the National Technical University of Athens (NTUA) and Head of the Laboratory for Maritime Transport of the School. He has a Diploma (1987) in NA&ME from NTUA (1987), an M.S. (1990) in NA&ME (Marine Systems Management) from the University of Michigan (UoM), an M.S.E. (1990) in Industrial and Operations Engineering (IOE) from UoM, and a Ph.D. (1990) in NA&ME from UoM as well. After finishing his graduate studies, Dr. Lyridis worked in various positions and disciplines: undertaking various technical and design studies for small high-speed boats; a large number of applied commercial projects in the areas of company restructuring, marketing, business and operational planning of Small and Medium Enterprises in Greece and in the EU as well as in developing countries; and a significant number of applied research projects. His main scientific areas of interest are maritime transport and logistics, shipping finance and economics, safety, security, and environmental protection. He is member of various scientific and professional societies in Greece and abroad including the Society of Naval Architects and Marine Engineers (USA), the International Association of Maritime Economists, and the Technical Chamber of Greece for which he is also member of one of its scientific committees.

Dr. Antonello Sala

Antonello Sala is scientific researcher at the National Research Council (CNR) in Ancona (Italy) with over 25 years of experience of studying the wider ecosystem effects of fishing on the marine environment. His main research interest includes fishing gear efficiency and energy saving, selectivity, engineering performance of the fishing gears at sea using underwater instrumentation, fishing gear design and modeling, netting material properties, physical and biological impacts produced in the marine environment by human activities. He is responsible of the Fishing Technology Unit and has been the main investigator and/or coordinator in several EU and national research projects (PREMECS-II, DEGREE, NECESSITY, ECOFISHMAN, MYGEARS, DISCATCH, BENTHIS, BYCATCH). His grant capture since 1990 exceeds 5M€, he has also worked numerous times as a scientific consultant and served on several national and international evaluation committees, such as for the Norwegian Research Council, EU-DGMARE and FAO. On 2014 and 2015 he has been contracted by the European Fisheries Control Agency (EFCA) as external expert for the contract “Assistance with the development of a methodology for the statistical and technical analysis of fisheries data” (EFCA/SER/2014-05/1127 and -/09/1127). In 2015 the European Parliament contracted him for an in-depth analysis “Alternative solutions for driftnet fisheries” (IP/B/PECH/IC/2014-082). Since 2010 he is member of the European “Scientific, Technical and Economic Committee for Fisheries (STECF)” and attended as expert in several

STECF and DGFISH/DGMARE Working Groups and many other international and national committees on fisheries. He has been nominated in 2015 STECF chair of the Expert Working Group “Mediterranean Landing obligation” (EWG 15-14) . He is holder of three patents pending and has published on this topic over 25 peer reviewed papers, 150 scientific/technical reports and publications in conference proceedings. He serves on the editorial board of the Open Journal of Marine Science, the Journal of Ocean Technology and the Journal of Agricultural Science and Applications. He is on the scientific committee of the international conferences on fishing engineering IMAM 2007, 2011, 2013, 2015 and e-Fishing 2010, 2014. Member of the Steering Committee for the development of the Publicly Available Specification for the “Assessment of life cycle greenhouse gas emissions – Supplementary requirements for the application of PAS 2050 to aquatic food products (PAS2050-2)” published by BSI Standards Limited. Since 2009 he is President of the National Commission UNITEX SC140 *”Fishing nets and ropes”*, for the standardization of the European textile sector within the Technical Committee CEN/TC248 *“Textiles and textile products”*. Since 2005 he is responsible for the Fishing Technology Unit at CNR. Since 2003 he is Chair of the *“Local Italian Chapter of the Eco-Ethics International Union (EEIU)”*. Since 2002 he is an official Member of the ICES/FAO Working Group on Fishing Technology and Fishing Behaviour (WGFTFB) and since 1999 he is Member of the Italian Society of Marine Biology (SIBM).

Professor Kristina Shea

Kristina Shea is full professor for Engineering Design and Computing in the Department of Mechanical and Process Engineering at ETH Zurich, Switzerland. She received her Bachelor (1993), Master (1995) and PhD (1997) in Mechanical Engineering from Carnegie Mellon University, USA. Professor Shea worked previously at universities in Switzerland (EPFL), United Kingdom (Cambridge University) and Germany (TU München). She also worked as a Senior Engineer in the Arup Foresight, Innovation and Incubation Group in London (UK) where she led the development of expertise in Computational Design and Optimization. Her research focuses on developing cutting-edge computational models, methods and tools that enable the design of more innovative and complex engineered systems and products as well as automate design and fabrication processes. Her research considers early conceptual design phases through to the fabrication of novel solutions including the topics of computational design synthesis and optimization, model-based systems engineering and computational design-to-fabrication, which focuses on design for additive manufacture. A variety of engineering areas are investigated including structures, MEMS, mechatronics, and robotics. These areas are then applied in a wide range of industries including automotive, aerospace, consumer products and buildings. Professor Shea is a Fellow of the American Society of Mechanical Engineers (ASME), Associate Editor of several international journals (ASME Journal of Mechanical Design, AIEDAM, and Design Science) and is currently an elected member of the Board of Management of the Design Society.

Professor Birgit Vogel-Heuser

Birgit Vogel-Heuser is the director of the Institute of Automation and Information Systems, at the faculty of mechanical engineering, Technical University of Munich, Germany. She received her diploma in electrical engineering from RWTH Aachen, Germany in 1987. She holds a PhD in mechanical engineering from RWTH Aachen. From 1991 to 2000, she has worked in the industry in the field of control engineering of complex machines and plants for multiple world market leading companies. Furthermore, she has worked at several universities in Germany in the field of electrical engineering and computer science. Her research interests include the modeling of distributed embedded systems in automation and control regarding dependability and usability, the Human-Machine Interaction in process engineering and operation. Professor Vogel-Heuser has served on the editorial board of multiple scientific journals as Editor in Chief and she has received several prizes for her contribution to her field of research. She has been on various boards and committees in the area of engineering and information technology.

The Research Council of Norway
Drammensveien 288
P.O. Box 564
NO-1327 Lysaker

Telephone: +47 22 03 70 00
Telefax: +47 22 03 70 01
post@rcn.no
www.rcn.no

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