The Research Council of Norway

Follow-up Plan for the Evaluation of Basic and Long-term Research within Engineering Science in Norway

Report from the Follow-up Committee on Recommended Actions

Evaluation
Division for Science

The Research Council of Norway

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Preface

The international panel, appointed by the Research Council of Norway (RCN) to evaluate the engineering science research in Norway, delivered its report "Basic and long term research within Engineering Science in Norway – Report from the principal evaluation committee" in April 2015. In June 2016 the RCN appointed a committee to make recommendations for follow-up actions. The findings of the evaluation, together with the suggested actions proposed by the evaluated organisations in response to a request from the RCN, served as background. Beyond this the follow-up committee have suggested any actions that it found suitable within the broader context of its mandate.

The committee members are:

- Ernst Kristiansen, Vice President Research, SINTEF Digital (leader)
- Helge Brattebø, Professor, Department of Energy and Process Engineering, NTNU
- Cecilie Rolstad Denby, Dean, Faculty of Science and Technology, NMBU
- Eva Dugstad, Director for Business Development at The Norwegian Radium Hospital Research Foundation
- Martin Fernø, Associate Professor, Department of Physics and Technology, UiB
- Randi Toreskås Holta, Vice Dean, Faculty of Technology, Natural Sciences and Maritime Sciences, HSN
- May Britt Myhr, Head of Department, Department of Petroleum Engineering, UiS
- Jostein Mårdalen, Head of Department, Department of Materials Science and Engineering, NTNU

Senior Adviser Bjørnar Solhaug Komissar at the Research Council of Norway has been acting as coordinator for the committee work. The follow-up committee has had five full day meetings.

1 Sammendrag

Basert på anbefalingene fra evalueringen av teknologifagene – i tillegg til innspill fra de evaluerte miljøene, en spørreundersøkelse rettet til forskningsgruppene som ble evaluert, samt oppfølgingsutvalgets diskusjoner i arbeidsmøtene – har utvalget identifisert ti prioriterte tiltak som anbefaling til oppfølging av teknologifagevalueringen. De anbefalte tiltakene er i henhold til utvalgets mandat, og er angitt i prioritert rekkefølge.

Hvert av de ti tiltakene er nærmere beskrevet i seksjon 4, sammen med en begrunnelse, en beskrivelse av de finansielle implikasjonene, og en angivelse av hvor hovedansvaret for en eventuell implementering av tiltaket ligger.

Den første anbefalingen er et særskilt tiltak som svarer på funnene fra både teknologifag-evalueringen og produktivitetskommisjonen. Teknologiforskningen i Norge har tradisjonelt vært tett knyttet til etablert industri, og i mindre grad til ny eller forestående industri; det er behov for å styrke eksellent og "blue sky" teknologifaglig forskning. Det første tiltaket er også det med størst kostnad av de ti som er foreslått, men er nødvendig for den langsiktige utviklingen av teknologi og teknologidrevet industri i Norge, spesielt i møte med post-petroleum-epoken.

Oppfølgingskomiteen har kommet frem til en felles forståelse av behov og til en omforent liste av følgende oppfølgingstiltak.

1. **Etablere sentre for fremragende forskning og finansiering av "blue sky" forsknings-prosjekter innenfor teknologifag** *(75 MNOK/år)*
2. **Styrke laboratoriefasiliteter og annen forskningsinfrastruktur** *(30-60 MNOK/år)*
3. **Stimulere internasjonal fagfellevurdert vitenskapelig publikasjon** *(8 MNOK/år)*
4. **Forbedre kjønnsbalansen innenfor teknologifagene** *(20 MNOK/år)*
5. **Fremme nasjonalt samarbeid, koordinering og ansvarsfordeling mellom universiteter, høgskoler og forskningsinstitutter** *(6 MNOK/år)*
6. **Stimulere til utvikling og bruk av strategier ved de ulike forskningsenhetene** *(2 MNOK/år)*
7. **Styrkning av internasjonalt forskningssamarbeid, forskermobilitet og deltakelse i EU-prosjekter** *(6 MNOK/år)*
8. **Etablering av nye nasjonale forskerskoler innenfor teknologifag** *(9 MNOK/år)*
9. **Styrket involvering av industriell og offentlig sektor for å stimulere innovasjon og utvikling av nye teknologier** *(4 MNOK/år)*
10. **Tillate internasjonal finansiering av kompetanseprosjekter i næringslivet**

2 Summary

Based on the recommendations from the Principal Evaluation Committee, feedback from the evaluated institutions, a questionnaire addressed to the evaluated research groups, as well as internal discussions, the committee has set up 10 prioritised actions as a recommendation to the follow-up plan for the evaluation. The recommended actions cover the mandate given to the committee and are presented in order of priority.

Each of the ten recommended actions is described in detail in Section 4, together with their justification, financial implication and responsible authority.

The first measure is an extraordinary action that responds to the findings from both the evaluation committee and the Productivity Commission (Produktivitetskommisjonen[1]). Technological research in Norway has traditionally been closely linked to established industry and does not sufficiently address new and "unborn" industry. There is a need for strengthening the excellent and "blue sky" technology research. This recommendation has the highest cost of the proposed actions, but is needed for the long term development of technology and technology-driven industry in Norway, particularly when meeting the post petroleum era.

The committee has developed a common understanding of the needs and commonly set up the action list.

1. **Establish centres of academic excellence (CoE) and "blue sky" project funding in engineering science** (*75 MNOK/Year)*
2. **Strengthen laboratory facilities and other research infrastructures** (*30-60 MNOK/Year*)
3. **Stimulate international peer-reviewed scientific publication** (8 MNOK/Year)
4. **Improve the gender balance in engineering sciences** (*20 MNOK/Year*)
5. **Promote national collaboration, coordination and sharing of responsibilities between universities, university colleges and research institutes** *(6 MNOK/Year)*
6. **Stimulate the development and use of research unit strategies** (*2 MNOK/Year*)
7. **Improved international research collaboration, researcher mobility and participation in EU projects** (*6 MNOK/Year*)
8. **Establish new national research schools in engineering science** *(9 MNOK/Year)*
9. **Strengthened industrial and public sector involvement to stimulate innovation and development of new technologies** *(4 MNOK/Year)*
10. **Acceptance of international funding in knowledge-building projects for industry**

[1] http://produktivitetskommisjonen.no/

3 Introduction

In 2014 the Research Council of Norway conducted an evaluation of basic and long-term research within technology. The report by the international evaluation panel, entitled "Basic and long-term research within Engineering Science in Norway - Report from the principal evaluation committee", was published in April 2015. In addition to this principal report, three reports covered specific research fields and documented the evaluation of the research groups within these fields:

- Panel 1: Energy and process technology
- Panel 2: Products, production, project management, marine systems and renewable energy
- Panel 3: Civil engineering and marine structures

The mandate from the RCN to the follow-up committee asks the committee to provide a follow-up plan for the evaluation, based on the findings from the evaluation and the recommendations of the principal report. The committee is also asked to take into account the follow-up recommendations provided by each of the evaluated institutions, as well as the considerations of the RCN.

The mandate states that the committee is to propose national level measures and actions; the following-up of the recommendations specific to each of the evaluated research groups is the responsibility of the institution in question. The actions may be discipline specific and/or of structural kind, and include both short-term measures and initiatives with a longer time horizon (5-10 years). The proposed actions are to be presented in order of priority with an indication of where the responsibility of implementation lies. The measures and actions must be within a realistic budget. The follow-up plan may also include advice to the Ministry of Education and Research and other relevant ministries regarding specific actions and/or financial needs.

The follow-up plan should include advice and recommendations on:

- Measures for the further development and strengthening of the research, as well as the research training and PhD education programmes, within technology research and engineering science
- Measures to promote national collaboration, coordination and sharing of responsibilities
- Measures to promote international research collaboration and mobility, in particular by means of increased participation in EU projects
- Measures to improve gender balance and to promote the recruitment to the technology disciplines, including PhD fellows; in particular the recruitment of women to permanent scientific positions
- Identification of specific areas within the technology disciplines that should be strengthened
- Publication strategies, in particular with the goal of increasing the number of publications in high ranked international journals with high impact factor
- Incentives/instruments that respond to the recommendations of the evaluation report
- Other strategic measures or actions that will contribute to further develop and to strengthen the technology research and engineering science in Norway, as well as the role of these disciplines within strategic research areas at national level

The follow-up committee has had five whole-day meetings discussing the follow-up actions. The committee agreed on how the recommended actions should be focused, and sent out a questionnaire to the evaluated research groups to get their feedback on the priority on the proposed actions. These responses, together with the judgement of the follow-up committee, have led to the final prioritisation of the recommended actions.

The principal evaluation committee focused on the missing "blue sky" research (high scientific quality and low relevance) for engineering sciences in Norway, as illustrated by Figure 1.[2] Note that these findings may not be representative for all disciplines within mathematics, natural sciences and technology since there are research groups that were not involved in the evaluation.

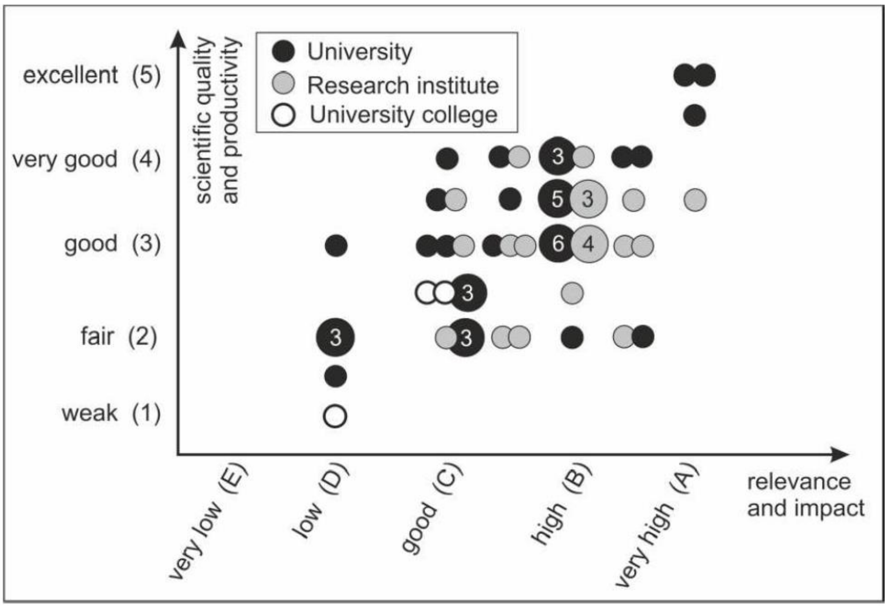

Figure 1: Quantification of the quality of the research (ordinate, y-axis) versus their relevance and impact (abscissa, x-axis) for all 64 research groups assessed. The markers indicate the type of the research groups ranked into university, research institute and university college. When there are 3 or more groups preforming equal (i.e. they are located at exactly the same point in the diagram) this is indicated by numbers in the dots. [2]

The 2016 report from the Productivity Commission (Produktivitetskommisjonen)[3] made a remark that Norway is lagging behind the other Nordic countries in Engineering and technology. This finding is well described in the "Report on Science and Technology Indicators for Norway – 2015"[4] and shown in Figure 2.

[2] "Basic and long-term research within Engineering Science in Norway, Report from the principal evaluation committee", Figure 2, page 8

[3] "Ved et vendepunkt: Fra ressursøkonomi til kunnskapsøkonomi", Produktivitetskommisjonens andre rapport, Norges offentlige utredninger 2016: 3, ISBN 978-82-583-1263-2, page 99-100

[4] "Report on Science and Technology Indicators for Norway – 2015", The Research Council of Norway, ISBN 978-82-12-03460-0 (pdf), page 20.

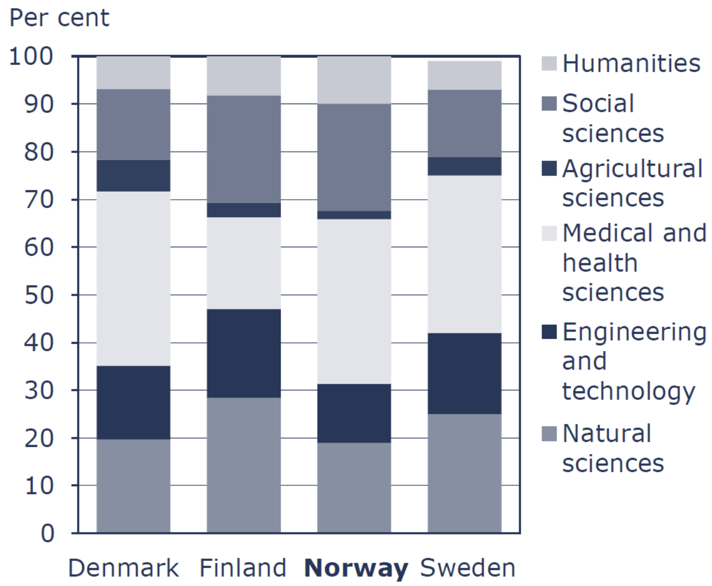

Figure 2: R&D expenditure in the higher education sector in Denmark, Finland, Norway and Sweden by field of research and development: 2013.[4]

The follow-up committee agreed with these findings, and the main recommended actions are directed towards activities to strengthen the scientific excellence.

4 Recommended Actions

In this section we first give an account of the context of the recommended actions, before these are presented in order of priority.

4.1 Context

The main and overarching goal for the research groups within engineering sciences will be to increase the long-term scientific performance of engineering science research and research education in Norway. This can be achieved by facilitating a strategic positioning of each engineering science research group towards one of three main categories of research profile. The evaluation panel mapped each research group's performance into a 2D scorecard according to the findings of the evaluation. The performance is measured with respect to scientific quality and productivity using a scale from 1 (weak) to 5 (excellent) and with respect to relevance and impact on a scale from E (very low) to A (very high). See Figure 3 below.

The evaluation panel's overall observation is that few groups perform at excellent levels on scientific quality and productivity and with no groups within "blue sky" research with less orientation towards high relevance and impact. Most groups are clustered in the middle of the scorecard. The scorecard also tells that a significant number of groups (20 out of 64) perform on the level of 2.5 or below on scientific quality and productivity, which overall is a result that strategically should be improved.

We recommend as a long-term strategy that every Norwegian research group within engineering science becomes well-positioned regarding performance level in one of the following three categories, each of a different characteristic:

- Academic excellence: Very good to excellent quality engineering basic science research of low short-term relevance and impact
- Industrial excellence: Very good to excellent quality engineering science research of high relevance and impact
- Industrial relevance: Engineering research of good scientific quality and high relevance and impact

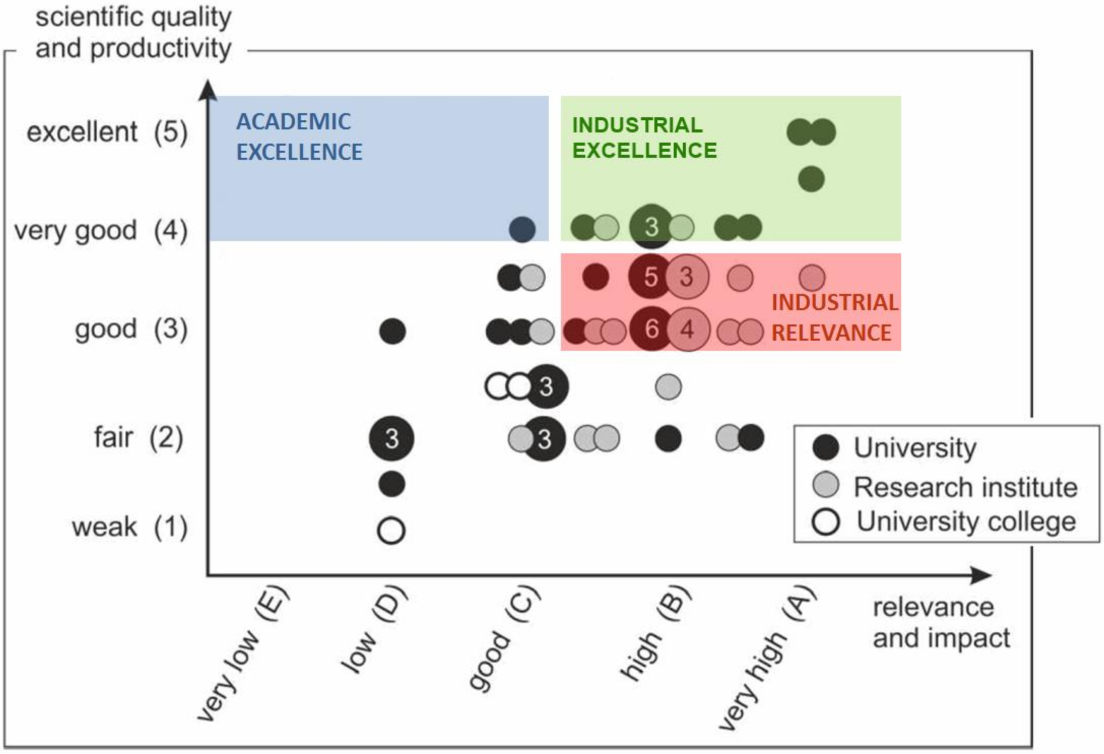

Figure 3: Distribution of evaluated research group within Norwegian universities, research institutes and university colleges with respect to scientific quality and productivity (weak to excellent) and relevance and impact (very low to very high). The national follow-up committee have identified three categories of national importance (academic excellence, industrial relevance, industrial excellence), where the majority of research groups should be located.

Academic Excellence

Very good to excellent quality within engineering basic science research of low short-term relevance and impact.

Research groups located in this category represent "blue sky" research of very good to excellent scientific quality and productivity, by international standards, on topics of less direct short-term relevance to society and industry. Industrial collaboration is less required in this category, with more focus on excellent links to peers internationally and top-level publishing and patenting. The groups in this category have an activity that depends on successful implementation of long-term ambitious strategies with a theoretical, methodological and fundamental technology focus. Such a technology science research profile is likely to be strongly linked to a natural science research profile, with targeted funding mechanisms such as SFF-programs (Centres of Excellence), Toppforsk and ERC.

Industrial Excellence

Very good to excellent quality engineering science research of high relevance and impact.

Research groups located in this category represent applied engineering research of very good to excellent scientific quality and productivity on topics of particularly high relevance to society and industry nationally and/or internationally. The research has high or very high return impact on society and industry; research results, recommendations and deliverables make a difference in policy and practice both in the short and long term. Such a leading position, nationally and internationally, is not realistically achievable for a large number of research groups, and can only be achieved and consolidated by strong focus on strategic development, internationalisation and excellence in methods, research infrastructure, choice of partners and publishing profile. Typically, the use of SFIs (Centres for Research-based Innovation) and strong involvement in international projects and networks are instruments to support this strategy, coupled with researcher projects and knowledge-building projects for industry linked to such research centre funding mechanisms.

Industrial Relevance

Engineering research of good scientific quality and high relevance and impact.

Research groups located in this category represent applied engineering research of high relevance to society and industry, particularly from a national perspective. This category prioritises national needs and strategies, with high impact on policy and practice in society and industry. The research is closely linked to industry, government and practical use, and often receives strong co-funding from such sources. A minimum of good scientific quality and productivity level is required, but ambitions to reach very good and excellent levels are not necessary; striving for a very high level of scientific quality and productivity requires strong focus on international activity and high-quality level publishing, and this can jeopardise resources needed to maintain high relevance and impact and close collaboration with industry. The instruments KPN (knowledge-building projects for industry) and IPN (innovation projects for the industrial sector) at the Research Council of Norway are important to manifest close collaboration.

We have elaborated a series of individual actions that we believe may serve well as strategic measures to move Norwegian engineering science research groups in the right directions towards the categories academic excellence, industrial excellence and industrial relevance. In the following we present these actions in order of priority.

4.2 Recommendations

Action 1: Establish centres of academic excellence (CoE) and "blue sky" project funding within engineering science

Description
Excellent research in engineering sciences as measured by academic standards, for example by publication points and citations, should be strengthened by establishing CoE in engineering science. Additionally, "blue sky" projects should be encouraged, possibly through dedication of an instrument similar to FRIPRO.

Justification
The evaluation of engineering science has revealed a need for strengthening academic excellence and what is called "blue sky" research in engineering sciences. This should be done by stimulating the development of some (relatively few) strong research groups by i) recruitment of excellent scientists, ii) stimulate cross-disciplinary collaboration in centres of academic excellence (CoE), iii) stimulate closer collaboration between natural sciences and engineering sciences, and iv) high level academic international collaboration. In addition there is a need for more of the relatively small "blue sky" research projects. This action point is a direct measure to correct the weaker technology research in

the Norwegian higher education sector compared to other Nordic countries (see Figure 2) as stated by the second report of the Productivity Commission (Produktivitetskommisjonen)[3].

Financial implications
75 MNOK/year. The calculated costs are based on three CoEs (15MNOK/year per centre) and 30 MNOK/year for FRIPRO in technology and engineering sciences.

Responsible
Ministry of Trade, Industry and Fisheries, Ministry of Education and Research, and the Research Council of Norway.

Action 2: Strengthen laboratory facilities and other research infrastructure

Description
The infrastructure program of the RCN should make a revised roadmap for the national research infrastructure with reference to the Long-term Plan for Research and Higher Education 2015-2024.[5] The roadmap should cover both large and smaller research infrastructures.

Justification
State-of-the-art research infrastructures are needed for excellent engineering science. This covers both the large research infrastructures and the smaller equipment. The basic funding for the research institutions does not cover their needs for investments and running expenses for their infrastructure. The infrastructure program at RCN has improved a lot during the last years, but there are still needs for further funding of both small and large infrastructure for engineering science.

Financial implications
30-60 MNOK/year. The infrastructure funding related to engineering science should be increased with 10 % per year over the next five years.

Responsible
Ministry of Trade, Industry and Fisheries, Ministry of Education and Research, and the Research Council of Norway**.**

Action 3: Stimulate international peer-reviewed scientific publication

Action 3a: High impact boost at individual level
Description
We recommend a pilot action to stimulate level 2 publications (i.e. high quality journals and other prestigious publication channels) by financially rewarding authors on individual basis, either as a salary addition or by financing research activities. Publications in level 2 journals give an individual incentive of 5.000 NOK per co-author per article. Each research institution must annually submit an application for its authors to receive the rewards. We suggest a pilot action of three to five years duration, where the evaluated research groups are the target.

[5] Kunnskapsdepartementet: Meld. St. 7, Langtidsplan for forskning og høyere utdanning 2015-2024

Justification
The number of level 2 articles in engineering science is about 250 annually, and the evaluation stated clearly that it was desirable to increase this number. Awards for the authors will be a clear incentive to increased publishing. The CRIStin database records all scientific publications, and it is easy to obtain an overview that can be updated almost continuously.

Financial implications
4 MNOK/ year. With 250 articles, an average of three Norwegian authors per publication and 5.000 NOK per author proportion will require in the order of 4 MNOK/ year. We recommend a budget with 10-20 % increase per year from 4 MNOK.

Responsible
The Research Council of Norway should administrate the funding scheme. It is recommended that the funding scheme is reviewed after the pilot time frame.

Action 3b: Increase Open Access publications
Description
In accordance with the proposed national guidelines for Open Access there should be incentives for Open Access publishing.

Justification
Open Access publishing is not mentioned in the evaluation report, but is included in the feedback from the research institutions. EU has stated that Open Access should be the default option when publishing results from publicly funded research. This action must be seen in context with the previous action to stimulate publishing. Should Open Access increase in volume, funding must be awarded not only to publishing in gold Open Access journals, but also to the so-called hybrid Open Access journals. The embargo time should be less than 12 months to be accepted as a hybrid Open Access journal.

Financial Implications
4 MNOK/ year. Full coverage of APC (Article Processing Charges) is in the order of € 2,000 per article by Gold Open Access. Assuming 100 articles published per year, with 20 % Open Access and 50 % funded from Norway, this would constitute 2 MNOK annually. If 40 % is achieved on hybrid Open Access, that has some fee to open the articles for Open Access, this may be an additional 2 MNOK. 4 MNOK/ year may be the expenses of moving large parts of the publications to Open Access.

Responsible
The Research Council of Norway.

Action 4: Improve the gender balance in engineering sciences
Description
A strong ambition is to increase recruitment of female researchers to permanent positions in engineering sciences. This is true for both academia and research institutes.

a. Five years pilot action. Institutions appointing female associate or full professors within the fields of technology and engineering science should receive a onetime cash contribution (200 KNOK/position).

b. Allocate earmarked funds to female researchers for travel, networking publication and sabbaticals (12 MNOK/year).
c. Publish a user guide with recommended gender balance actions based on previous experience. Present statistical data for gender balance at discipline and faculty level.
d. A strengthened mandate for the KIF committee[6] (Committee for Gender Balance and Diversity in Research) to place stronger emphasis on gender balance in technology and engineering science (No financial implication).

Justification
Studies show[7] that female researcher career development is slower compared to their male colleagues. The gender balance in technology and engineering sciences deserves special measures. Although the responsibility for career development mainly lies with the institutions, the national measures listed above aim to stimulate institutions to work harder on improving the gender balance in technology and engineering sciences. Experience from local implementation, the impact, effect and success of gender balance measures should be collected, analysed and made readily available to inspire, recommend and augment decision-making for future measures. Gender balance strategy, and actual results, should also be on the agenda in the Ministry's annual follow-up of the individual institutions (*in Norwegian: Styringsdialog)* to give incentives to improvements on gender balance. The Ministry of Education and Research will appoint a new Committee for Gender Balance and Diversity in 2017, and will have the opportunity to adjust its mandate to include a particular focus on this field.

Financial implications
20 MNOK/year. The financial implications for each of the listed measures are mentioned above.
a. 7 MNOK/year. 200 KNOK per position, estimated 35 female positions annually in engineering sciences.
b. 12 MNOK/year. 20 projects/year earmarked for female researchers with 50 % salary coverage.
c. 1 MNOK.
d. No financial implication.

Responsible
Ministry of Education and Research and the Research Council of Norway.

Action 5: Promote national collaboration, coordination and sharing of responsibilities between universities, university colleges and research institutes

Description
Use adjunct positions for increased collaboration across universities, university colleges and research institutions. Avoid thematic overlap through development of coordinated research initiatives nationally; thematic overlap between the sectors should be kept to a minimum. Use the TRL (technology readiness level) description as a tool to coordinate and clarify research and engineering

[6] http://kifinfo.no
[7] Jorun M. Ulvestad, Myter i omløp - Det annet kjønn i akademia, Uniped nr 1 2016, s 3-4, and references therein, Hovdehaugen, Kyvik og Bruen Olsen: *Kvinner og menn – like muligheter? Om kvinners og menns karriereveier i akademia* , Oslo: NIFU-STEP skriftserie 25/2004

responsibilities between academia and research institutes. Clarify and specify the difference between innovation and competence-building projects, both in project management and evaluation criteria.

Justification
Increased national cooperation will be of benefit for the researcher communities and should be promoted. The innovation and competence-building projects today are too similar, and the full potential for each project type is not fully utilised/explored.

Adjunct positions for increased collaboration across institutions and sectors have been an excellent tool for developing common understanding and research. It will be easier to get national learning arenas and matchmaking events with the purpose of building stronger national groups that can compete internationally. It will avoid thematic overlap through development of coordinated research initiatives nationally.

Financial implications
6 MNOK/year. Adjunct positions as described above require 5 MNOK/year. National learning arenas and matchmaking events would be the main responsibility of the research institutions themselves, with co-funding of 1 MNOK from the Research Council of Norway.

Responsible
The Research Council of Norway and the research institutions.

Action 6: Stimulate the development and use of research unit strategies

Description
Research groups that today are under-performing should be stimulated to develop clear research group strategies.

a. Over the next 2-3 years 4-8 projects/year should be established to stimulate the development and use of research strategies.
b. In larger RCN applications, such as CoE, SFI and FME, the research unit strategy of the applicant, together with the CVs for key personnel, should be submitted in the proposal.

Justification
The principal evaluation committee claims that there is a lack of strategic plans in the research units, or that the strategy is not sufficiently well known within the units. This is obviously a challenge for research institutions and groups that aim to systematically improve. The follow-up committee agrees that clear strategies are important. One way of increasing the value of a strategy document is to use it actively in project applications, not necessarily as an absolute demand, but rather to strengthen the content of the application on the strategic level.

According to the evaluation panel, 20 groups perform below "good" on scientific quality and productivity. To mitigate this situation the RCN, together with the institutions themselves, could finance a few projects per year to develop or improve research strategies that target weak groups. Such projects can, for example, be in the form of workshops, seminars or courses to aid research groups in establishing and implementing a unified research strategy for each group.

Financial implications
2MNOK/year. 4-8 projects.

Responsible
The Research Council of Norway.

Action 7: Improved international research collaboration, researcher mobility and participation in EU projects

Description
Increase POS (*In Norwegian: Posisjoneringsmidler)* for strategical, long-term positioning of Norwegian engineering science interests. Increase the number of international top-level experts hired as adjunct positions at Norwegian engineering research institutions.

Justification
Participation in international research networks, European technology platforms, and strategic collaboration with top-level experts are important for strategic positioning and initiation of engineering science research. These measures will also increase Norwegian visibility in EU, and increase the active international research participation and mobility in the long run.

Financial implications
6 MNOK/year. Dedicated POS funding (3 MNOK/year) and 3 MNOK/year to international top-level experts as adjunct positions in engineering sciences. Collaboration between Norwegian institutions is encouraged.

Responsible
The Research Council of Norway and the Ministry of Education and Research.

Action 8: National research schools in engineering science

Description
Establish three new national research schools in engineering science.

Justification
Of the 22 research schools currently funded, only few are within technology and engineering sciences. National cooperation on research schools will encourage establishments of networks among young scientists. Recruitment of female PhD candidates in engineering and technology should be emphasised through targeted activities such as research camps and establishment of female networks. This action should be accompanied by campaigns that aim at recruiting the female students into research by establishing research camps and offering network activities for master students.

Financial implications
9 MNOK/year. 3 MNOK/year per research school.

Responsible
The Research Council of Norway.

Action 9: Strengthened industrial and public sector involvement to stimulate innovation and development of new technologies

Description
Targeted projects or clusters should be made in order to develop improved collaboration between engineering science research groups and industrial and public sector actors to enhance innovation. Industry/public sector doctoral scholarships can be used to support such initiatives along with making industry experts available for adjunct positions at engineering research institutions.

Justification
The evaluation committee report shows that many research groups do not reach a high or very high relevance and impact score (see Figure 1). The follow-up committee believes this is a critical factor, and therefore suggests that measures are taken specifically to improve the collaboration between certain research groups and industrial and public sector actors. The RCN could fund a limited number of targeted projects (4 research groups, 3 years funding each) with budgets for travel, events, development work and temporary adjunct positions (part time) for industry persons to spend time at research groups. The industry/public sector doctoral scholarships instrument could contribute in this respect, but the RCN should evaluate the instrument because progress and scientific outcome of such candidates vary too much.

Financial implications
4 MNOK/year. RCN funding, distributed over four projects, with co-funding by institutions and industry.

Responsible
The Research Council of Norway and institutions/industry.

Action 10: Acceptance of international funding in knowledge-building projects

Description
Acceptance of international industrial cash as co-funding for knowledge-building projects between academic and industrial partners on RCN funded projects.

Justification
International collaboration between research institutions and industrial partners will be strengthened if cash co-funding from abroad could be used as the industrial matching funding in RCN funded projects. This will also encourage new technologies to be developed nationally; international funding can be used to initiate research within a technological area where Norway has expertise and research capabilities, but there are no Norwegian company capable of providing the cash funding needed to get a knowledge-building project.

Financial implications
None.

Responsible
The Research Council of Norway, Ministry of Trade, Industry and Fisheries, and Ministry of Education and Research.

5 Conclusion

Technological research in Norway has traditionally been closely linked to established industry, and it has been dependent on the industry's willingness and ability to finance the work. The Norwegian technological research institutes have a high degree of industrial relevance. However, for the long term development of technology and technology-driven industries in Norway, particularly when meeting the post petroleum era, there is a need for an instrument that does not rely on an established industrial need. Such an instrument should address new industries, as well as the unknown industries of the future. Hence, there is a strong need to strengthen "blue sky" research, defined as research with high quality and potential in the future. The follow-up committee has therefore prioritised the establishment of new centres of excellence (CoE) in engineering sciences as an important means to renew the Norwegian industry in a long term perspective. This recommendation has the highest cost but aligns well with the main findings on the evaluation report.

The follow-up committee has during its work focused on national-level measures, and consequently avoided recommendations that target individual research groups, research areas or institutions. In 2014, the evaluation panel assessed each research group on their scientific quality and industrial relevance. A large range was observed, but it was concerning that 20 of 62 evaluated groups perform below "good" in scientific quality and productivity. Hence, there is a need to lift these groups to increase quality and relevance, and to identify mechanisms and pathways for research groups to maintain or increase their current high quality and/or relevance. The follow-up committee therefore early defined three focus areas (see above for full description), with the goal that all research groups in Norway should belong to either of the following areas: academic excellence, industrial excellence and industrial relevance. The recommended measures listed in the summary and described in detail above align with the recommendations from the principal report: It is important for the future of engineering sciences in Norway that all three of these areas are populated with a sufficient number of robust groups. The recommended actions aim to position the evaluated research group into these areas. The follow-up committee has also emphasised the importance of labour and to create national teams in the defined areas.

The follow-up committee issued a questionnaire to all the evaluated groups to receive up-to-date information regarding their current challenges, strategies and research focus. This has been an important tool for the follow-up committee, and has been used complementary to the findings of the principal report to prioritise the recommended actions as outlined in the summary, together with their justification, financial implication and responsible authority.

Appendices

A Mandate

This section gives the mandate for the work carried out by the national committee that was appointed by the Research Board for the Division for Science at the Research Council of Norway. The task was to propose measures on national level on how to follow up the recommendations from the evaluation worked. The committee consisted of eight members affiliated with institutions that were part of the evaluation, and its work was facilitated and supervised by the administration of the Research Council. The mandate was prepared and approved in Norwegian.

Mandat

Med utgangspunkt i evalueringsrapportene (én hovedrapport og tre panelrapporter ferdigstilt i april 2015) og planen for oppfølgingsarbeidet som vedtatt av Divisjonsstyret for Vitenskap, inviterte Forskningsrådet de evaluerte miljøene til å beskrive det følgende:

1. Forslag til oppfølgingstiltak som bør utføres på nasjonalt nivå.
2. Innspill til hvordan de, alene eller i samarbeid med andre, kan bidra til den nasjonale oppfølgingen.
3. Beskrivelse av egne oppfølgingsplaner og -tiltak, samt rapport om hvordan disse har blitt fulgt opp på institusjonsnivå.

I henhold til planen for oppfølgingsarbeidet skal institusjonenes innspill til tiltak vurderes av et utvalg oppnevnt av Forskningsrådet ved Divisjon for vitenskap (DSV). Utvalgets arbeid skal gjennomføres i nær dialog med Forskningsrådet, som vil delta som observatør.

Oppfølgingsutvalget skal lage et forslag til en oppfølgingsplan for teknologifagevalueringen med utgangspunkt i funnene i evalueringen og hovedrapportens anbefalinger. Utvalget skal også legge til grunn Forskningsrådets vurderinger og forslagene til tiltak mottatt fra forskningsmiljøene. I tillegg skal det i starten av utvalgets arbeid holdes et felles møte hvor utvalget, representanter fra de evaluerte institusjonene og representanter fra Forskningsrådet deltar. Forslag og diskusjoner som fremkommer fra dette møtet vil være en del av utvalgets underlag.

Oppfølgingsplanen skal i størst mulig grad gi konkrete råd og anbefalinger til tiltak som kan utføres på nasjonalt nivå. Tiltakene kan være av faglig og/eller strukturell karakter, og de kan omfatte både kortsiktige tiltak og tiltak med en lengre tidshorisont (5-10 år). Foreslåtte tiltak skal presenteres i prioritert rekkefølge med angivelse av hvem som bør ha hovedansvaret for gjennomføring av de ulike tiltakene. Alle tiltakene skal være innenfor en realistisk budsjettramme. Planen kan også gi råd og anbefalinger til Kunnskapsdepartementet og andre relevante departement om spesifikke tiltak og finansielle behov.

Planen skal inkludere råd og anbefalinger om:

- Tiltak for videreutvikling og styrking av forskningen og forskerutdanningen innenfor teknologifagene
- Tiltak for å fremme nasjonalt samarbeid, koordinering og arbeidsdeling
- Tiltak for å fremme internasjonalt forskningssamarbeid og mobilitet, spesielt via økt deltakelse i EU-prosjekter
- Tiltak som kan forbedre kjønnsbalansen og fremme rekrutteringen til teknologifagene, inkludert PhD-stipendiater; spesielt rekruttering av kvinner til faste vitenskapelige stillinger

- Identifisering av spesifikke områder innenfor teknologifagene som bør styrkes
- Publiseringsstrategier, spesielt med målsetning om økt publisering i høyt rangerte internasjonale journaler med høy *impact factor*
- Bruk av virkemidler for å følge opp evalueringens anbefalinger
- Andre strategiske tiltak som vil bidra til å utvikle og styrke forskningen innenfor teknologifagene i Norge og disse fagenes rolle innenfor nasjonale strategiske forskningsområder

Utvalget bes om å ferdigstille planen innen 11. november 2016. Rapporten skal være kortfattet (maks 20 sider) og skrives på engelsk. Før ferdigstilling skal planen sendes ut til evalueringskomiteen og de evaluerte miljøene for kommentarer. De evaluerte miljøene skal også inviteres til et felles møte hvor planen presenteres og kommentarer fra miljøene diskuteres og tas til etterretning av utvalget i ferdigstillingen av rapporten. Det tas sikte på at oppfølgingsplanen blir forelagt Divisjonsstyret for Vitenskap ved utgangen av 2016 eller i januar 2017.

B Description of Committee Members

- Ernst Kristiansen, Vice President Research, SINTEF Digital (leader)
- Helge Brattebø, Professor, Department of Energy and Process Engineering, NTNU
- Cecilie Rolstad Denby, Dean, Faculty of Science and Technology, NMBU
- Eva Dugstad, Director for Business Development at The Norwegian Radium Hospital Research Foundation
- Martin Fernø, Associate Professor, Department of Physics and Technology, UiB
- Randi Toreskås Holta, Vice Dean, Faculty of Technology, Natural Sciences and Maritime Sciences, HSN
- May Britt Myhr, Head of Department, Department of Petroleum Technology, UiS
- Jostein Mårdalen, Head of Department, Department of Materials Science and Engineering, NTNU

Ernst Kristiansen is Vice President Research at SINTEF Digital. Kristiansen worked 5 years at research institutes and 11 years in industry before he joined SINTEF in 1992. Kristiansen has been in the top management of SINTEF since 1995. Kristiansen is a member of the boards of EARTO, FFA and CRISTin, and he is a member of the European Open Science Policy Platform. Kristiansen's main work at SINTEF is related to Research Policy. His latest research areas are connected to quantity analysis of research collaboration. He has long experiences with analyses and evaluations of participation in EU framework programmes (FP6, FP7 and H2020).

Helge Brattebø is Professor of Industrial Ecology at NTNU Faculty of Engineering Science & Technology, with 30 years academic experience in environmental engineering, industrial ecology and environmental systems analysis. He was the founding director of NTNU's Industrial Ecology Programme and has been visiting professor at Yale University and the MIT-Portugal Programme at Univ. of Lisbon. Brattebø has supervised 26 PhD students and some 60 MSc students, he is co-editor of *Journal of Industrial Ecology*, has published 60 peer-reviewed international journal articles, and he has been involved in several national and international research projects.

Cecilie Rolstad Denby is Dean of Faculty of Science and Technology at the Norwegian University of Life Sciences. She is a professor in Geomatics, with long experience from remote sensing in the polar regions. Rolstad Denby has a PhD from UiO/Ohio State University/Byrd Polar Research Center, and has worked at British Antarctic Survey and Utrecht University. She has supervised several master and phd students in Arctic projects using radar remote sensing, and was head of Division of Glaciers and Ice sheets of International Association of Cryospheric Sciences from 2012-2014.

Eva S. Dugstad is Director for Business Development at The Norwegian Radium Hospital Research Foundation. Until January 2017 she was Special Adviser at Institute for Energy Technology (IFE) within Innovation. She has a master of science in Pharmacy. She was IFE's President in 6 years from May 2010. She has also had the positions as Executive Vice President, Research Director and Head of Department at IFE and been the Chair of IFE Venture, IFE's company for commercialisation of research results.. She has been working as a member or chair in several Boards and working groups, where the most important are as a member of the Board of Faculty of Mathematics and Natural Science at University of Oslo, member of the Board of Division for Science at Norwegian Research Council, member of the Board of Confederation of Norwegian Enterprise (NHO), vice chair and member of the Board of Abelia, Chair of the Board of IFE Venture, member of OECD's Steering committee for Nuclear Energy Agency, member of Halden Board, Chair of GIAMAG Technologies, member of NEL ASA and Energy 21. She was also a member in the panel in 2011 which evaluated the scientific quality at “Risø Forsøksanlegg” after they had become a part of Danish Technology University (DTU).

Martin A. Fernø is Associate Professor in the Petroleum and Process Technology research group at the Department of Physics and Technology, University of Bergen. His research focuses on flow in porous media, oil recovery and CO2 storage, with emphasis on in situ imaging. His scientific interests include spontaneous imbibition, foam flow and combined CO2 storage and enhanced oil recovery. He has over 80 scientific publications and supervised more than 60 PhD and master students in Petroleum Technology at the Dept. of Physics and Technology.

Randi Toreskås Holta is Vice Dean at Faculty of Technology, Natural Sciences and Maritime Sciences at University College of Southeast Norway. She earned her doctoral degree in theoretical physics from NTNU in 1996. She has long experience from teaching, supervision and course and program development at Master and PhD-level. For the past five years she has been the head at the Department of Electrical Engineering, Information Technology and Cybernetics at Telemark University College.

May Britt Myhr is Head of Department Petroleum Engineering at the University of Stavanger. She has a master of science in chemistry from NTNU, and has experience from oil and gas research, development and innovation. The last two decades Myhr has worked mainly as a manager concentrating on strategy development and implementation. Myhr has been CEO of SINTEF Petroleum Research and Strategy Director of Oil and Gas at SINTEF. She has experience as board member of a wide range of national committees and company boards including OG21, Intsok, Aker Exploration ASA, Sevan Marine ASA and MultiClient Geophysical ASA. Myhr has been Chair of the Board of NCE Instrumentation; and from January 2017 she is chairing the Board at the Faculty of Science and Technology at NMBU.

Jostein Mårdalen is Head of the Department of Material Science and Engineering at the Faculty for Natural Sciences at NTNU. Mårdalen has a PhD in physics from NTH and has been an active researcher within the field material science at both NTNU and SINTEF. His main scientific contributions have been on electro-active (conducting) polymer materials, X-ray diffraction and imaging and surface science and characterisation. During the recent years Mårdalen has been focusing on management and strategic work within the fields of education and research. He is heading or participating in several strategy groups and Boards of Directors both in the industry and research organisations, and in a variety of research projects and programs.

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