

Research Centre for Low-emission Technology for Petroleum Activities
on the Norwegian Continental Shelf (NCS)

Midterm evaluation PETROSENTER 2022

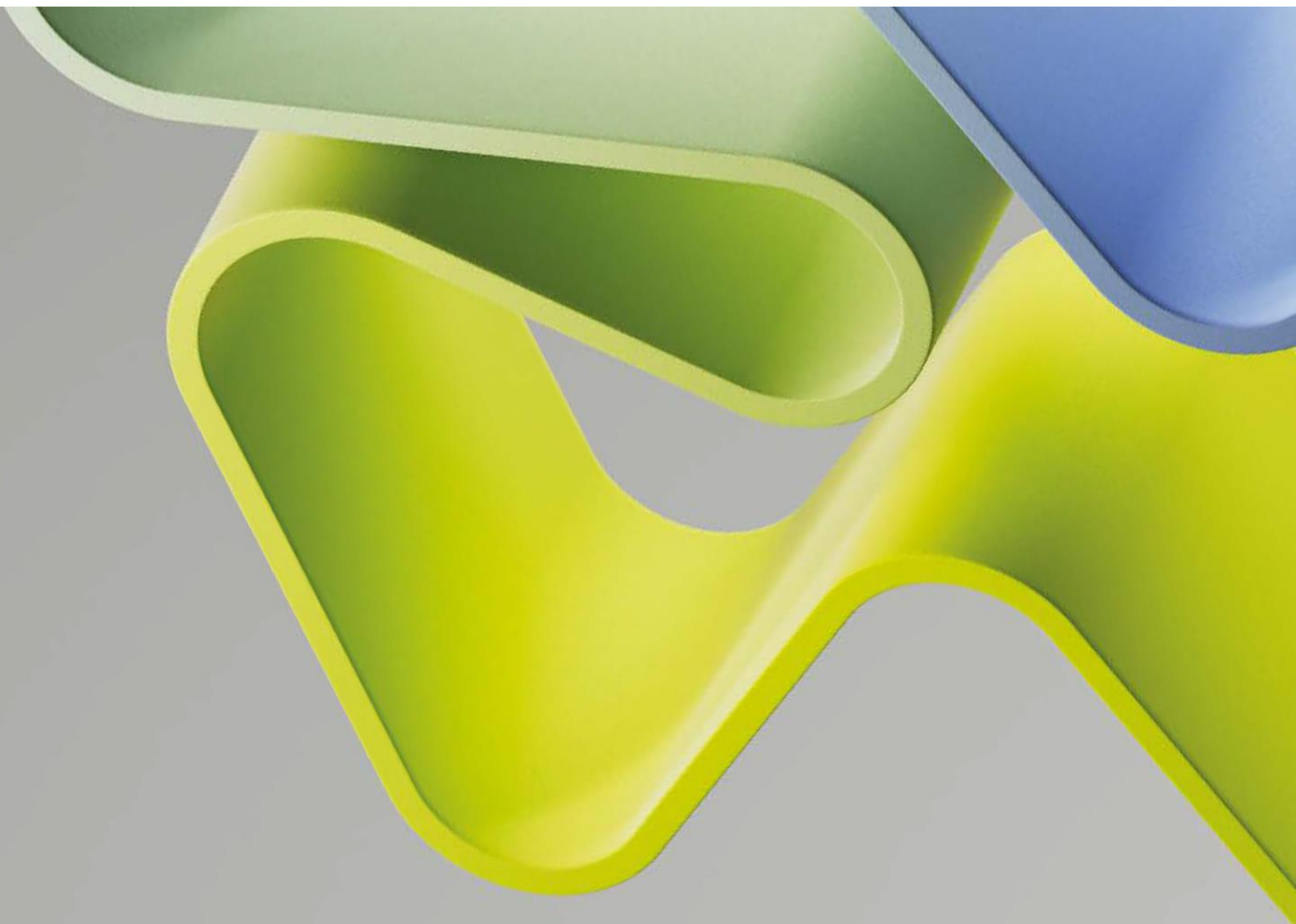


Table of contents

Preface		3
Introduction		5
Research activities		5
Cleaner energy supply	6	
More efficient energy use and other emissions	7	
Whole system activities	8	
Recommendations	9	

Internationalisation		9
Researcher training and engagement in education		10
Recommendations	11	

Plans for final three-year period		11
Recommendations	11	

Organisation and Management of the Centre		12
Recommendations	13	

Innovation and value creation		14
Recommendations	14	

Funding and financial aspects		15
Recommendations	15	

Gender aspects		15
Recommendation	16	

Impacts on emissions from the Norwegian Continental Shelf		16
Recommendations	17	

Conclusions and Recommendations to RCN		17
Appendices		20

Preface

Research Centre for Low-emission Technology for Petroleum Activities on the Norwegian Continental Shelf (NCS)

A call in 2018, under the PETROSENTER scheme, was aimed at establishing a Research Centre for Low-emission Technology for Petroleum Activities on the Norwegian Continental Shelf (NCS). Visions and objectives for the call were:

- Develop zero- or low-emission technologies which enables future development and operations of petroleum resources with the lowest possible greenhouse gas emissions
- Develop technology that helps to significantly reduce emissions from existing offshore installations.

The following centre was awarded funding, and is the scope of the present evaluation:

Project number: 296207

Project title: Research Centre for a Low-Emission Petroleum Industry on the Norwegian Continental Shelf

Project owner (host institution): SINTEF ENERGI AS

Start date: February 1, 2019

This report presents the mid-term evaluation of this centre. The evaluation was carried out by a panel of three international experts and one generalist:

- Alison McKay (panel leader), University of Leeds
- Gioia Falcone, University of Glasgow
- David Ingram, University of Edinburgh
- Lars Nordström, KTH – The Royal Institute of Technology

The terms of reference, given in Appendix 1, describe further the objective of the evaluation, the evaluation questions and the methodology.



Introduction

On 4th October 2022 the evaluation team met with the Chair and members of the Steering Board, the Director, partner representatives and PhD students. In the morning the discussions focused on the research at the Centre and there was a meeting with PhD students. In the afternoon there were discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on discussions at this site visit and on the written report and self-assessments supplied beforehand. We thank all members of the Centre for their efforts in providing information for the evaluation and for the open and constructive discussions on the day of the visit.

Overall, the Panel found evidence of a strong bottom up approach driving work in all scientific areas through the Centre's sub-projects, with the majority supported by at least one PhD student. However, there was a lack of scientific coordination across the sub-projects which risks compromising the Centre's impact, especially in the final three years when innovations that reduce emissions on the NCS are likely to draw on and integrate findings from multiple scientific areas. Further, the organisational structure, and the way in which reporting lines are implemented, reflects this emphasis on working individual scientific areas. For example, the Centre has a Scientific Committee (but it is not independent), representation of international academics is limited and its remit only covers the PhD students. The Panel identified this, and the need for more subject-specific objectives against which the Centre's performance can be judged, as critical areas for improvement before the beginning of the final three years. Key scientific recommendations relate to the definition of: low emissions scenarios for the NCS that can be used to drive the Centre's work and associated mid-level objectives for the Centre that focus on the delivery of reduced emissions on the NCS. With respect to Centre organisation, key recommendations relate to ensuring processes are in place for effective communication within the Centre, and the establishment of a Centre-level International Scientific Advisory Board whose members (including the chair) are independent of the Centre and its members. Finally, the Centre has a number of so-called "Premium projects" whose relationship with the Centre requires further clarification.

Research activities

At the site visit the Centre Director provided an overview of the scientific research in the Centre (reproduced in Figure 1). There is evidence of strong research activity driven by a bottom-up approach from the Centre's sub-projects. However, there is a risk that the Centre will not capitalise fully on potential impacts from activities spanning multiple sub-projects. This is a particular concern for the final three years of the Centre where innovations leading

to reductions in emissions are to be delivered. The remainder of this section evaluates the research activities of the Centre with respect to the structure in Figure 1.

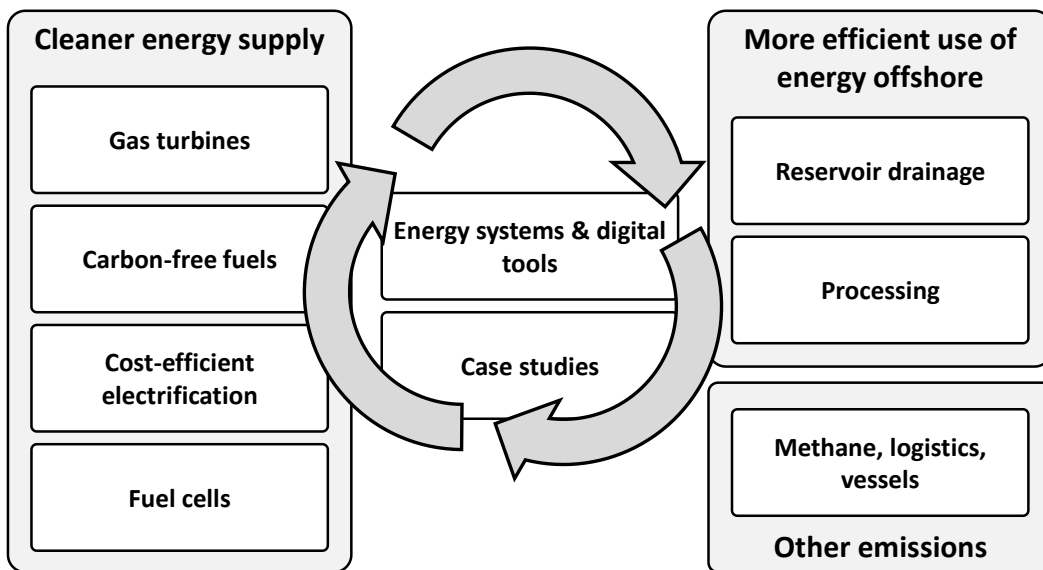


Figure 1: Overall structure for the Centre's research [copied from the Centre Director's presentation]

Cleaner energy supply

Four sub-projects are active in this thematic area: SP1 (*Efficiency enhancement of gas turbines*), SP2 (*Carbon free firing of gas turbines*), SP3 (*Reduced cost of electrification*) and SP4 (*Fuel cells for zero emission heat and power*).

SP1 and SP2 have been conducting fundamental research to reduce the carbon emissions associated with the gas turbines. In 2018, on the NCS, they were responsible for the emission of 9.74 MT (CO₂ equivalent) representing the largest source of emissions considered by the Centre. SP1 is exploring changes in operating strategies needed for turbines running at part load (e.g., when power from offshore wind turbines is used to replace some of the electrical power demand) and bottoming cycles using both steam and alternative working fluids such as CO₂. It is supporting one PhD student. SP2, on the other hand, is conducting fundamental research into the burning properties and flame structure of H₂-NH₃ mixtures with the aim of using them as fuels for firing gas turbines in place of the normal natural gas feed. It is currently sponsoring three PhD students and actively cooperates with the University of Darmstadt who are providing a placement and access to internationally leading experimental facilities for one of the students. SP1 and SP2 cover closely related areas of research, leading to joint case studies on the Johan Castberg vessel and the Elgin and Franklin fields. A spin out project, LINCCS, was initiated in a collaboration with two SINTEF groups: LowEmission and the Norwegian CCS (Carbon

Capture and Storage) Research Centre NCCS. Further, two spin out projects (DigitalTwin and DECAMMP) are associated with SP1. Within SP3, which supports one PhD, the activities on subsea connectors and wet design cables are well coordinated and showing promising results. Engagement with industry to set priorities and targets for SP3 appears to be working well. In response, there is also work within SP3 on modelling of electrification scenarios to analyse the environmental impact of offshore electrification. Work on the further development of the EMPIRE and PowerGIM open-source tools (using the Julia programming environment) has the potential to be linked with activities in SP5. However, progress on developing these links was unclear to the Panel.

Work in SP4 relates to two kinds of fuel cell: PEM (Proton-Exchange Membrane) and PCFC (Protonic Ceramic Fuel Cell). The primary achievement of SP4 is the establishment and use of a testing protocol for the assessment of the performance of fuel cells operated under dynamic load conditions. In addition, stable performance has been demonstrated under reversible operation for a tubular PCFC. The budget for SP4 is very small when compared with the other sub-projects and no PhD students are affiliated with it. For this reason, the Centre management team may consider it appropriate either to discontinue work in this area or integrate it with that of another sub-project.

More efficient energy use and other emissions

Three sub-projects are active in this thematic area: SP7 (*Energy efficient drainage*), SP8 (*Energy efficient processing*) and SP9 (*Other emissions*).

SP7, with one PhD student, is working in close collaboration with industry partners to identify energy efficient drainage strategies and develop models coupling subsurface flow to topside operations, aiming to optimise energy consumption and emissions. SP8, again with one PhD student, is also working in close collaboration with industry partners to identify areas with high potential for reducing energy demand and consumption, and enhancing energy recovery. Given its aim to develop coupled subsurface-surface modelling, the Centre has recognised the need for closer collaboration between SP7 and SP8, and work is already ongoing along this direction. Enhancing synergies between SP7 and SP8, and with SP5 (*Energy systems – digital solutions*), will facilitate the adoption of integrated solutions towards more efficient energy use. No experimental work is planned under SP8. Instead, the development of new concepts, modelling and optimization tools, and guidelines is being prioritized with a view to accelerating implementation of existing solutions and management strategies for existing fields. It will therefore be key to obtain real (or realistic) field data inspired by real typologies (and associated management best practices) of existing fields in the NCS, for which direct industry engagement and data/information sharing will be essential.

SP7 and 8 are using existing frameworks to build integrated model that enable the assessment of overall system performance when optimizing production strategies and testing the impact of new equipment or technologies with an emission reduction potential. However, from the information available to the evaluation team, it was difficult to identify the scientific novelty of SP7 and SP8 vis-à-vis the modelling capabilities of existing software tools for Integrated Asset Management (IAM). For example, commercially available and open source IAM tools already allow users to couple models for reservoir, wells, surface facilities and field economics. In addition, although IAM does not routinely perform quantification of the CO_{2eq} emissions associated with a given field operation scenario, users can plug in OpenServer modules converting energy consumption to CO_{2eq} emissions (using standard conversion formulae). To identify the novelty of the outputs from SP7 and SP8, it would be beneficial to present a systematic comparison of modelling capabilities of the Centre's new modelling and optimisation tools against those of existing commercial and open-source solutions. This will help the Centre to characterize the superior capabilities of their new tools and so facilitate uptake by end-users.

SP9, with one affiliated PhD student, aims to reduce emissions from mobile units through logistics optimization and zero-emission vessels, including the development of better technologies for methane emissions mapping and abatement. SP9 has already interacted synergistically with SP4. SP9 also has the potential for impact beyond Scope 1 emissions, e.g., in the case of future transboundary shipping scenarios.

Whole system activities

Two sub-projects cover the whole system and so are critical to delivering the impacts required by the Call: SP5 (*Energy systems and digital tools*) and SP6 (*Case studies*). Researchers in SP5 carry out a range of activities related to the modelling of integrated offshore energy systems. Activities focus on the optimisation of such systems and outputs are largely in the form of open-source software. A reference platform has been used to generate synthetic data for use by other activities. In addition, the HyOpt model for planning low emission investments has been further developed. Three PhD students are affiliated with SP5 and several scientific publications have been presented or are in preparation. However, linkages between the activities in the sub-project are not clear, although each individually appears to be producing relevant results of high quality.

The cross-cutting case studies being developed in SP6 (with which no PhDs are directly associated though some are involved from other sub-projects) have the potential to play a strategic role in offering a testbed for verification and validation of new solutions emerging from the other sub-projects. They also represent an opportunity to capture different low emission scenarios for existing and new fields, which could be related to the overarching challenge defined in the Call, and be decomposed into sub-challenges to be addressed by

individual or groups of sub-projects. For the final three years, it is vital that the industry partners take an active role in the generation and support of the cross-cutting case studies. SP6 also provides strategic opportunities to compare business-as-usual scenarios with truly novel ones (see Section 7).

In summary, whilst there is evidence of a strong, bottom up, approach driving the work in the sub-projects we were concerned that the lack of scientific coordination across the sub-projects will dilute the Centre's impact. Our first three recommendations seek to ensure a more joined up approach between the sub-projects together with a clear method for demonstrating the impact of the Centre's innovations and research outputs. The fourth recommendation seeks to promote the Centre's activities as a whole, with a view to ensuring the widest possible visibility and recognition of the Centre's work in the scientific community.

Recommendations

1. That the sub-project leaders collectively specify, or use from other sources, future low emission scenarios (to 2050) for the NCS to drive the Centre's activities for the final three years.
2. That the sub-project leaders collectively formulate mid-level objectives for the Centre that are both related to the scenarios from Recommendation 1 and defined in a way that encourages cross-cutting research activities across the sub-projects.
3. That the Board and Centre Director approve the mid-level objectives from Recommendation 2 before the beginning of the final three years.
4. That the Centre adopts an auditable approach for the definition of metrics and the evaluation of research and innovation activities against the mid-level objectives.
5. That the Centre defines a publication plan to ensure the international visibility and peer recognition of its scientific activities and findings.

Internationalisation

There is clear evidence of research cooperation with international groups. For example, in the meeting with PhD students, two joined remotely from overseas institutions where they were working: TU Darmstadt and Carnegie Mellon University. It is less clear, however, if this collaboration has come about thanks to the Centre or if it is existing networks of participating researchers that have enabled this collaboration.

Opportunities for EU funding in oil & gas are limited though the Centre has one affiliated project, RETURN, to which the EU contributes. There is some collaboration with international research groups and visits to the Centre by visiting researchers. Now that Covid restrictions are lifting, in the final three years the Panel encourages more

collaboration with academics outside Norway to ensure international visibility of the Centre and cross fertilisation of research ideas.

Researcher training and engagement in education

The Centre is currently sponsoring 11 PhD students who are registered with NTNU for their degree programmes. Five students have been able to participate in long term international exchanges with leading university groups and research centres. All the students are valued members of their sub-project families, but the Panel felt they could benefit from guidance from industrial partners both to develop their non-academic skills and to ensure their projects deliver impact for the Centre.

The Panel was impressed by the quality and enthusiasm of the PhD students we met and by their diverse range of backgrounds. It was clear that, while the Covid pandemic has had a limited impact on the students' abilities to access laboratories and make academic progress, it has limited their opportunities for social interactions so reducing both opportunities for networking and the development of the cohort as a whole. Such interactions are extremely beneficial to student wellbeing and activities to support further development of the cohort, with support from the Centre, could be organised by the students themselves: for an example, see the INORE symposia¹.

Internationally, many Doctoral Training Centres strive to bring added value to their PhD programmes by building on their research themes and industrial links. Beyond being a member of a sub-project family, the Centre's PhD students are not seeing such added value. Since NTNU PhD programmes include at least 30 ECTS of coursework there is an opportunity for the Centre to work with its industry partners to develop a credit bearing course on low emission technology. Such a course, including site visits, field trips and real-world project-based learning, would ensure the students share a common language and understand the broader issues and industrial context of their work. Student education would be further enhanced by providing secondment opportunities with SINTEF, companies, regulators, and government². The Centre is also working with MSc students on dissertation projects and placements. In addition to providing a mechanism for recruiting PhD students to the Centre, this can also provide an enthusiastic and informed workforce for SINTEF and partners organisations.

¹ Research student-led INORE symposia: <https://inorean.org/inore-european-symposium-2022/>

² <https://post.parliament.uk/uk-research-and-innovation-policy-internships/>

Recommendations

6. That NTNU staff develop a credit bearing course on low emission technologies which could be taken by students from the Centre and other students with an interest in low emission technologies.
7. That the Centre provides more opportunities for students to meet socially and informally, to discuss their work and share experiences.
8. That the Centre identifies an industrial advisor as a formal member of the supervisory team for each PhD student.

Plans for final three-year period

The Centre presented a plan for the final three-year period that also includes activities beyond the planned Centre lifetime. The plan very much builds on the established sub-projects and presents only a small number of minor modifications to the research objectives and methodology defined in the proposal. In the plan, the achievements of the Centre towards its KPIs are presented and it is clear that many of the targets are already met or will shortly be met. Of course, this is generally positive, but it does also raise the question of whether the KPIs are appropriate and/or if the targets are not sufficiently ambitious. The plan also outlines three distinct areas for improvement as identified by the Centre management team: the gender diversity of the PhD students, the need to increase the publication of results in leading journals, and the need to increase the collaboration between the partners in the Centre, specifically the industry partners.

Given the requirement from the Call for the Centre to deliver results that lead to reduced emissions on the NCS, the Panel was concerned that the plan for the final three-year period lacks detail in how this will be achieved. However, at the site visit, the Centre Director demonstrated the Centre's commitment to ensuring the delivery of such impacts and presented a number of initiatives (e.g., innovation challenges) that could be used to deliver them. To ensure that this is prioritised in the final three years, the plan for the final three years needs to include specific milestones and deliverables related to the low emission scenarios (see Recommendation 1) and more detailed plans for collaboration across the sub-projects.

Recommendations

9. That the Centre, given the new mid-level objectives from Recommendation 2, adjusts the KPIs and targets for the final three year period to ensure that the delivery of results contributing to reduced emissions are prioritised by the Board.
10. That the Centre defines concrete actions to address the three areas of improvement identified in the SWOT: i.e., the gender diversity of the PhD students (see

Recommendation 23), the need to increase the publication of results in leading journals (see Recommendation 5), and the need to increase the collaboration between all partners in the Centre.

Organisation and Management of the Centre

The Centre is hosted by SINTEF in collaboration with NTNU. Nine of the ten sub-projects are led by SINTEF staff, and one, SP2, is led by a member of NTNU staff. PhD students are hosted and awarded their degrees by NTNU and co-supervised by staff from SINTEF and NTNU. The Centre's annual reports are presented in a professional manner and their content gives a good overview of the Centre's activities. Its webinar programme is an effective way of engaging with wider research groups and users. Now that Covid restrictions have been lifted we encourage the Centre to consider holding in-person events, such as research seminars, where in addition to technical content there are opportunities for social interaction both within the Centre and with people outside the Centre.

To date, the Centre's activities have been led primarily from within the sub-projects where research ideas are developed in collaboration with industry partners. Within each sub-project, a sub-project family is used as a mechanism to evaluate, coordinate and further develop activities within each sub-project area. While there are some activities that span multiple sub-projects (e.g., the Director introduced one on power fluctuation control that includes SP1&5 and another spanning SP4&9 on requirements for the use of fuel cells on off-shore vessels), the management team's role tends towards coordinating these activities and contextualising them with respect to the Centre's goals. This may have been appropriate for the first half of the project. However, for the final three years, where innovations developed through technology-readiness levels are likely to benefit from input from multiple sub-projects, a more proactive leadership style from the Board and Centre management team coupled with a clear scientific vision for the Centre as a whole (and with direct links to future emissions scenarios for the NCS) will be necessary. In addition, although the Scientific Committee is in place and has met once (in early 2022), its remit appears to be limited to the PhD projects. Given that the current PhD projects do not cover all sub-projects, and that some activities are not carried out by PhDs, this arrangement creates two concerns. Firstly, not all activities are subject to international review until the submission of publications and, secondly, the Scientific Committee does not consider the scientific activities of the Centre as a whole. In addition, the membership of the Scientific Committee is, with one exception, national; the majority of members are not independent because they belong to organisations that are members of the Centre; and the chair of the Scientific Committee is a member of the Centre. In summary, the Scientific Committee needs to be made internationally diverse and chaired by someone who is independent of the Centre.

At the site visit it was refreshing to see the impact of the leadership team's open management style which meant that all parties were able and willing to contribute to the discussion. Further, from the documentation provided before and during the site visit, the Centre appears to be well-organised with effective administrative systems in place. However, although the Centre has an agreed organisational structure, the responsibilities of some groups (e.g., the Scientific Committee and the Technical Committee of Innovation and Commercialisation) and reporting lines between them and the Board and Centre Management team (SP10)) were unclear. The summaries presented at the site visit did not appear wholly consistent with those in the table at the beginning of Section 7 in the Centre's self-evaluation report.

The Centre is carrying out a number of case studies in collaboration with industry partners under the auspices of SP6. Each case study includes at least one industry partner and, with the exception of SP4 (Fuel cells for zero emission heat and power), each sub-project is contributing to at least one case study. Several case studies involve more than one sub-project and, as such, are an effective way of encouraging collaboration between the Centre's research partners. For the final three years, more collaboration between research partners across different sub-projects is likely to be needed because solutions to real-world problems will demand the integration of knowledge from multiple sub-projects. The Centre's case studies, along with initiatives such as the innovation mapping exercise and innovation challenges, are likely to be effective ways of focussing the Centre's research in its final three years. However, there is also a need for clear mid-level objectives and realistic low emission scenarios (see Recommendations 1 and 2). A concern with the case studies to date lies in their time-limited nature; we encourage more flexibility in the definition of timescales for case studies. For example, a pilot phase might be used to better understand the problem and resources (e.g., data and time) needed to address it that could then inform timescales for the delivery of the case study.

The fact sheet lists a number of affiliated projects, largely funded by Norwegian organisations, several of which are identified as so-called "Premium" projects that are described as being funded by surplus industry funding to the Centre. These projects involve several partners, but it is unclear how they relate to the Centre, e.g., in terms of ownership of results and IP, and finances.

Recommendations

11. That the Centre establishes an independent International Scientific Advisory Committee with Terms of Reference that ensure the Centre's activities, as a whole, are subject to external review and feedback.

12. That the Centre defines terms of reference for each element of the management structure and reporting lines between them.
13. That the Board puts in place processes to ensure that reporting lines are implemented across the Centre.
14. That the Centre's management team and sub-project leaders create and maintain a Centre-level risk register for the final three years.
15. That the Centre, in collaboration with RCN, clarifies the position of the Premium projects in the Centre, including financial arrangements, and ownership of results and IP.
16. That the Centre ensures all PhD students associated with Premium projects are fully integrated into the Centre's researcher training programme.

Innovation and value creation

Innovation is a key ambition of the Centre and requirement of the Call. The Centre offers a unique blend of academic, scientific and industrial engagement to deliver innovative technologies and solutions for reducing climate gas emissions in the NCS by 50% within 2030, and for moving towards zero-emission within 2050.

The Centre's activities focus solely on Scope 1 emissions, i.e., emissions 'in operation'. Given the parallel national net-zero targets and those of other Centres and projects in Norway (including spin-off and premium projects triggered by LowEmission itself), a transparent strategy is needed to determine what constitutes an 'innovation' within the Centre and whether or not a given innovation derives directly from the Centre's activities. In a way that is recognized both nationally and internationally, it would be beneficial for the Centre to establish an innovation and commercialisation plan based on its innovation map; the map could be revised, e.g., on a 6-monthly basis, to ensure that progression of the Centre's innovative technologies and solutions is monitored on a regular basis. This would allow strategic prioritisation of resources and efforts, early identification of (co-)ownership, and leadership towards commercialisation.

The Case Studies of SP6 represent not only a testbed for verification and validation of new solutions emerging from the sub-projects but also an opportunity to capture innovative low emission scenarios (see Section Research activities). SP6 also represents an opportunity for industry placements of Centre researchers that could lead to additional joint publications and facilitate knowledge transfer.

Recommendations

17. That the Centre's industry partners take an active role in the generation and support of cross-cutting case studies.

18. That the Centre agrees on criteria for identifying innovation opportunities arising from the Centre's research activities.
19. That the Centre ensures clarity on which activities, outputs and intellectual property are owned by the Centre and/or other initiatives including the Premium and other affiliated projects.
20. That the Centre builds an innovation and commercialisation pathway plan based on the innovation map and the mid-level objectives and associated scenarios from Recommendations 1 and 2.

Funding and financial aspects

The Centre has a good level of support from a large number of partners and, overall, its financial performance is as one would expect. To date, less than 10% of resources have been allocated to case studies and other forms of activity that draw together knowledge and capabilities from multiple sub-projects. For the final three years, this should be increased to ensure that the potential for impact from the Centre is maximised.

The Centre's research has resulted in several affiliated projects, including some that are identified as "Premium projects". These projects are funded by surplus industry funds coupled with funding from other sources (e.g., RCN's Petromaks2 scheme). This creates confusion because the projects appear to be funded by a mix of Centre and other funding, and issues such as the ownership of intellectual property is unclear.

Recommendations

21. That the Board sets aside at least 20% of the budget to allocate to industry case studies to be allocated by the Centre Director in conjunction with the TCIC and management team. In addition to promoting innovation, this will help foster cross cutting activities at a Centre-wide level.
22. That, for future reporting periods, the Centre management team ensures clarity on whether or not activities are funded by the Centre or other initiatives, including the Premium projects.

Gender aspects

Some areas the Centre have good gender balance whilst others are imbalanced. For example, although both the Centre Director and the Centre Manager are women, five out of the nine administrative and technical staff, seven out of 17 Board members, 10 out of the 41 senior staff members, one of the nine sub-project leaders, two of the 10 PhD students and none of the Scientific Committee are women. The Panel was especially concerned by the limited participation of women as sub-project leaders and members of the Scientific

Committee. The RCN's BALANSE programme notes that, "Improved gender balance will lead to a more equitable research system and ensure that society can benefit from research expertise from the entire population." Whilst workforce demographics may make it difficult to do so, the Centre should seek to appoint more women as sub-project leaders.

Work on student recruitment in Science and Engineering has shown that women are encouraged to apply to projects and programmes when the bigger pictures and outcomes of the work are emphasised and when inclusive language is used in job adverts³. Applicants are also encouraged when they can see role models like themselves working in the area. In future rounds of PhD student recruitment, the Centre should carefully review the language used in adverts and promote positive and diverse images of researchers drawn from the Centre staff. Emphasising the development of highly sought-after skills and strong employment prospects in a decarbonised oil & gas sector may also encourage Norwegian students to apply. This could be further encouraged by the introduction of internships with SINTEF, project partners and government agencies.

Recommendation

23. That the Centre works proactively to increase the gender diversity, specifically in the student body and the scientific advisory board.

Impacts on emissions from the Norwegian Continental Shelf

The Centre provided evidence of ongoing activities well in line with the strategic priorities of the PETROSENTER low emissions call. There is however very weak traceability between the Centre's activities on progress towards *the estimated potential reductions of emissions from the NCS* (e.g., see project description Fig 4, page 9). One method with which to ensure such traceability would be definition of mid-level goals and related metrics as recommended in Section Research activities. Similarly, *the developed technologies' potential contribution to energy production/efficiency* is not clearly articulated in the presentation of the individual activities in the sub-projects. Here again, relating the activities to a mid-level objective would alleviate this.

³ <https://raeng.org.uk/policy-and-resources/d-i-resources/inclusive-recruitment>

Recommendations

24. That the Centre Director, Board and management team, reformulate the plan for the final three years to ensure that it prioritises the delivery of outputs most likely to have the highest impact on emissions on the NCS.
25. That the Centre's sub-project leaders ensure that the Centre's activities within and across the sub-project areas prioritise the delivery of outputs most likely to have the highest impact on emissions on the NCS.
26. That the Centre's reconstituted Scientific Advisory Committee meets and provides a report giving feedback on the scientific quality of the sub-projects' research and plans, and its fit with the Centre's reformulated plan for the final three years, before the beginning of the final three years.

Conclusions and Recommendations to RCN

The Centre is carrying out scientifically strong research in its sub-projects that has resulted in outcomes of significant interest to the user partners and relevant to Norway's carbon emissions targets. This mid-term evaluation has highlighted areas which could be improved further and accordingly our recommendations to improve the Centre are as follows.

1. That the sub-project leaders collectively specify, or use from other sources, future low emission scenarios (to 2050) for the NCS to drive the Centre's activities for the final three years.
2. That the sub-project leaders collectively formulate mid-level objectives for the Centre that are both related to the scenarios from Recommendation 1 and defined in a way that encourages cross-cutting research activities across the sub-projects.
3. That the Board and Centre Director approve the mid-level objectives from Recommendation 2 before the beginning of the final three years.
4. That the Centre adopts an auditable approach for the definition of metrics and the evaluation of research and innovation activities against the mid-level objectives.
5. That the Centre defines a publication plan to ensure the international visibility and peer recognition of its scientific activities and findings.
6. That NTNU staff develop a credit bearing course on low emission technologies which could be taken by students from the Centre and other students with an interest in low emission technologies.

7. That the Centre provides more opportunities for students to meet socially and informally, to discuss their work and share experiences.
8. That the Centre identifies an industrial advisor as a formal member of the supervisory team for each PhD student.
9. That the Centre, given the new mid-level objectives from Recommendation 2, adjusts the KPIs and targets for the final three year period to ensure that the delivery of results contributing to reduced emissions are prioritised by the Board.
10. That the Centre defines concrete actions to address the three areas of improvement identified in the SWOT: i.e., the gender diversity of the PhD students (see Recommendation 23), the need to increase the publication of results in leading journals (see Recommendation 5), and the need to increase the collaboration between all partners in the Centre.
11. That the Centre establishes an independent International Scientific Advisory Committee with Terms of Reference that ensure the Centre's activities, as a whole, are subject to external review and feedback.
12. That the Centre defines terms of reference for each element of the management structure and reporting lines between them.
13. That the Board puts in place processes to ensure that reporting lines are implemented across the Centre.
14. That the Centre's management team and sub-project leaders create and maintain a Centre-level risk register for the final three years.
15. That the Centre, in collaboration with RCN, clarifies the position of the Premium projects in the Centre, including financial arrangements, and ownership of results and IP.
16. That the Centre ensures all PhD students associated with Premium projects are fully integrated into the Centre's researcher training programme.
17. That the Centre's industry partners take an active role in the generation and support of cross-cutting case studies.
18. That the Centre agrees on criteria for identifying innovation opportunities arising from the Centre's research activities.
19. That the Centre ensures clarity on which activities, outputs and intellectual property are owned by the Centre and/or other initiatives including the Premium and other affiliated projects.
20. That the Centre builds an innovation and commercialisation pathway plan based on the innovation map and the mid-level objectives and associated scenarios from Recommendations 1 and 2.
21. That the Board sets aside at least 20% of the budget to allocate to industry case studies to be allocated by the Centre Director in conjunction with the TCIC and management team. In addition to promoting innovation, this will help foster cross cutting activities at a Centre-wide level.

22. That, for future reporting periods, the Centre management team ensures clarity on whether or not activities are funded by the Centre or other initiatives, including the Premium projects.
23. That the Centre works proactively to increase the gender diversity, specifically in the student body and the scientific advisory board.
24. That the Centre Director, Board and management team, reformulate the plan for the final three years to ensure that it prioritises the delivery of outputs most likely to have the highest impact on emissions on the NCS.
25. That the Centre's sub-project leaders ensure that the Centre's activities within and across the sub-project areas prioritise the delivery of outputs most likely to have the highest impact on emissions on the NCS.
26. That the Centre's reconstituted Scientific Advisory Committee meets and provides a report giving feedback on the scientific quality of the sub-projects' research and plans, and its fit with the Centre's reformulated plan for the final three years, before the beginning of the final three years.

Appendices

1. Terms of reference



Terms of Reference

Background

The scope

A call in 2018, under the PETROSENTER scheme, was aimed at establishing a Research Centre for Low-emission Technology for Petroleum Activities on the Norwegian Continental Shelf.

Visions and objectives for the call were:

- Develop zero- or low-emission technologies which enables future development and operations of petroleum resources with the lowest possible greenhouse gas emissions
- Develop technology that helps to significantly reduce emissions from existing offshore installations.

The following centre was awarded funding, and is the scope of the present evaluation:

Project number:	296207
Project title:	Research Centre for a Low-Emission Petroleum Industry on the Norwegian Continental Shelf
Project owner (host institution):	SINTEF ENERGI AS
Start date:	February 1, 2019

The PETROSENTER scheme

The PETROSENTER scheme establishes time-limited research centres that conduct targeted, focused, long-term research of high international calibre with the aim of addressing specific challenges for management of and value creation from Norwegian petroleum resources.

The inclusion of companies in the centre's activities is one of the requirements. Public enterprises may also participate in the centres' activities. Company partners and public enterprises that participate in the centre's activities are referred to as "*user partners*".

Industry-oriented researcher training and long-term competence-building is of vital importance. The centre's research activities and competence-building must be carried out in close cooperation with operators and licensees on the Norwegian continental shelf. Knowledge development and technological research at the centre must enhance the ability of operators to implement new measures to reduce offshore greenhouse gas emissions from the Norwegian continental shelf.

Research should be the core activity of the centre. Nevertheless, it is important that adequate resources are set aside for administration and joint activities. This is essential for safeguarding the added value created by organising research activities as a centre; i.e. a foundation must be laid for effective coordination between the various segments of the centre and for centre-building activities and activities that promote effective involvement of user partners.

With its long timeframe and ample budgets, the centre scheme creates a solid foundation for enhanced international research cooperation. The centre must set aside an adequate amount of funding for activities to promote international cooperation, such as international project collaboration and mobility grants. The centre may also be asked to represent Norway and the Research Council in international arenas for cooperation.

The financing and duration of the centres

The centre should be co-financed by the project owner, the centre's research partners and user partners, and the Research Council. The user partners shall take active part in the centres' management, financing and research activities. The centres are established for a period of maximum eight years (5 + 3).

Purpose of the evaluation

A midterm evaluation is outlined in the document "Requirements and guidelines", which reflects the contents of the call for applications and is a part of the centre contract.

The midterm evaluation of the centre should be conducted under the auspices of the Research Council roughly 3.5 years after start-up. This mid-term evaluation will be conducted using the Research Council's procedures for centre evaluations and on the basis of a mandate decided by the Research Council's governing bodies.

The purpose of the evaluation is two-fold:

1. The midterm evaluation, any comments from the centre and the evaluation of the administrative situation form the basis for the Research Council's decision to either extend operation of the centre for a total of eight years after start-up or to close it down five years after start-up.
2. The Research Council may include the evaluation advice on how to improve and further develop the centre in stipulations of the decision and the renewed contract, if the centre is granted the final three-year extension.

Evaluation questions

The evaluation will review progress of scientific and industrial efforts, recognising it is still early in the centre period. The evaluators will form an opinion concerning the approach and measures taken so far by the centre to judge the potential for their long-term development towards a successful completion of the centre. Evaluators may offer suggestions for remedial action to enhance the prospects for centre success. The evaluation and suggestions for remedial actions must be within the framework of the call and the contract between the Research Council and the project owner.

The innovation activities and the cooperation between researchers and user partners in the centre must be thoroughly evaluated. It's important to elucidate the role of the centre in mobilizing both small and large enterprises to research and innovation activities. The centre's plans and steps taken to ensure that research results will be taken forward to innovations used by the industry, are of high importance, in order to reach the expected impacts in the call.

Success criteria

The evaluation team will make the evaluation in the context of the success criteria (Appendix 1).

Relevance to the call and special stipulations

In addition to the success criteria, the evaluation should also assess:

- to which extent the centre activities are fulfilling objectives in the call (relevance).
- to which extent the centre research outputs will give impacts that contribute to reduction of greenhouse gas emissions from the petroleum activities on the Norwegian Continental Shelf to 50 % within 2030 compared to 2005 and close to zero in 2050.
- to which extent the centre has succeeded in fulfilling any special stipulations in the decision made by The Research Council's board committee.

Not to be included

To avoid giving a premature indication of The Research Council's decision concerning continuation or discontinuation of the centre, the evaluation panel is asked not to comment specifically on this issue.

The organisation

The evaluation panel

The centre will be evaluated by a panel of four international experts. The Research Council will decide whom to invite. Research Council of Norway's guidelines on impartiality and confidence apply for the experts, and all persons involved in the evaluation and decision process.

The competence profile of the panel will include scientific expertise within the fields of the center and experience from similar programmes for academia/industry collaboration. One of the members of the panel will be appointed as the panel leader.

Administrative assessment

In addition to the evaluation questions addressed by the evaluation panel, the Research Council's staff will evaluate the administrative framework at the centre. This assessment will be based on the formal reporting scheme to the Research Council (e.g. progress reports, project account reports, project changes).

Methodology

The evaluations will be carried out on the basis of written background material and interview sessions during a site visit.

Background material for the evaluation

The following written material, written in English, will form the background for the evaluation:

1. Report from the centre according to a standardized outline, featuring relevant information, including: A self-evaluation of the centre including sections on research accomplishments, important industrial or social results and potential for innovation, network, internationalisation, recruitment, financial aspects and organisation. The self-evaluation will also contain a research plan for the final three years.
2. A fact sheet according to a template including CV for the management team, data for the staff working in the centre, list of publications, PhDs. candidates, financial data and selected indicators.
3. Annual reports from the centre (2019, 2020, 2021).
4. Work program for 2022 (including tables for costs and funding).
5. Present description/plan for final three-year period, including a plan for the post-funding phase.
6. A report and self-evaluation from the host institution.
7. A report and self-evaluation from each of the user partners.
8. A report and self-evaluation from each of the research partners.
9. Report from Scientific Advisory Board/Scientific Committee.

Provided by the Research Council:

- INFORMATION FOR APPLICANTS Research Centre for Low-emission Technology for Petroleum Activities on the Norwegian Continental Shelf
- For 296207:
 - Present contract including project description and Requirements and guidelines.
 - The collaboration agreement.
 - Special stipulations in the Research Council decision in 2018
- A fact sheet to supplement information in the above bullet points, if necessary.

Site visit

During the site visit the evaluation team should meet:

- The Centre Leader
- The Chair of the Centre Board
- Representatives from the user partners
- Representatives from collaborating research institutions
- Host institution staff incl. representatives from the top management
- Research leaders active within the Centre
- Doctoral students and postdoctoral fellows

The Research Council staff will be present at the site visit. The staff will act as administrators and should not take active part in the evaluation, but can add information during work sessions of the panel. The administrative assessment will be carried out independently.

The site visit will be planned as a physical meeting in Trondheim, with a virtual back-up solution (Teams or Zoom) in case of Covid-19 restrictions. It will be carried out according to a standardized agenda. It will be divided into two main sessions, one session devoted to the research activities and one session devoted to organisation and innovation aspects. There will also be a separate session with the PhD students and postdoctoral fellows.

The evaluation report

The evaluation report should be written in consensus by the evaluation team. The report should be written in English. A draft template for the report will be provided by the Research Council. The report should include comments on the self-evaluation reports and the site visit. Information from the self-evaluation reports should be given only in a summarized or anonymous form, not identifying answers from individual partners.

Before submission to the Research Council of Norway the centre shall be allowed to check a draft report for factual errors.

The Portfolio board for petroleum will make the decision concerning continuation or discontinuation of the centre. After the decision, the report will be made publicly available on the web pages of the Research Council.

Time frame

- The background material will be distributed by The Research Council of Norway to all members of the evaluation panel no later than one month prior to the site visit.
- The site visit will take place late September / early October.
- The evaluation panel must submit the report to The Research Council of Norway, no later than six weeks after the site visit.

Attachment: Success criteria

The following criteria will be relevant in assessing the success of the centre throughout its period of operation:

Research activity

- The centre has a distinct research profile, conducts long-term, relevant research of high international standard in the field specified in the project description, and demonstrates this through the achieved doctoral degrees,

scientific publications, papers for presentation at respected international conferences and other forms of scientific recognition.

- The centre utilises a multidisciplinary approach in its research activities; i.e. it forges close links between various subject areas within natural science and technology disciplines, and integrates social science disciplines as needed.
- Researchers from the host institution and research partners participate actively in the centre's research.

Relevance and benefit to users

- The centre is visible in national and international arenas where questions concerning petroleum activities and recovery of petroleum resources are discussed.
- The centre has implemented measures to ensure that the expertise and results achieved through research are effectively transferred to and utilised by the user partners, and, in general, works actively with the dissemination of research results to a broader range of user groups and the public at large.
- The centre has achieved reciprocal mobility of personnel between the centre and centre partners.
- The centre's user partners have increased their research involvement over time as a result of their participation in the centre's activities.

Internationalisation

- The centre has distinguished itself internationally (e.g. researchers associated with the centre have received awards or been invited to be keynote speakers at international conferences).
- The centre has achieved good standing in international research cooperation.
- The centre engages in active and binding collaboration with international research groups and has contributed in other ways to the internationalisation of Norwegian research. The centre engages in active and binding collaboration with international research groups and has contributed in other ways to the internationalisation of Norwegian research. The centre has at least one international partner of some renown.
- The centre attracts outstanding international researchers, including research fellows and senior staff, as visiting researchers.

Researcher training and recruitment

- The centre has an effective framework in place for researcher training, and helps to train highly skilled personnel in the centre's areas of specialisation.
- The centre is actively engaged in education, especially at the master's and doctoral levels, and promotes recruitment to the centre's subject areas, including increased recruitment of women.

Partners and funding

- The centre has long-term funding from the host institution and partners.
- The centre works actively to attract new partners that contribute funding.
- The centre has been successful in securing other external funding.

Organisation

- The centre has a visible profile, a strong identity and has established successful collaboration between its partners.
- The centre has achieved a satisfactory gender balance in the research.
- The centre is organised in a manner that is closely aligned with the host institution's organisation.
- The centre has a board and management which ensure that the intentions and plans underlying the establishment of the centre are followed up.
- The centre has a unified administration with a high degree of scientific and administrative autonomy.
- The centre has documented the added value of organising the activities as a centre.

Norges forskningsråd

Besøksadresse: Drammensveien 288

Postboks 564

1327 Lysaker

Telefon: 22 03 70 00

post@forskningsradet.no

www.forskningsradet.no

Publikasjonen kan lastes ned fra

www.forskningsradet.no/publikasjoner

Design: Anti

Foto/ill. omslagsside: CATK

ISBN 978-82-12-03956-8 (pdf)

