The Research Council of Norway

# Evaluation of Mathematics, ICT and Technology 2023-2024

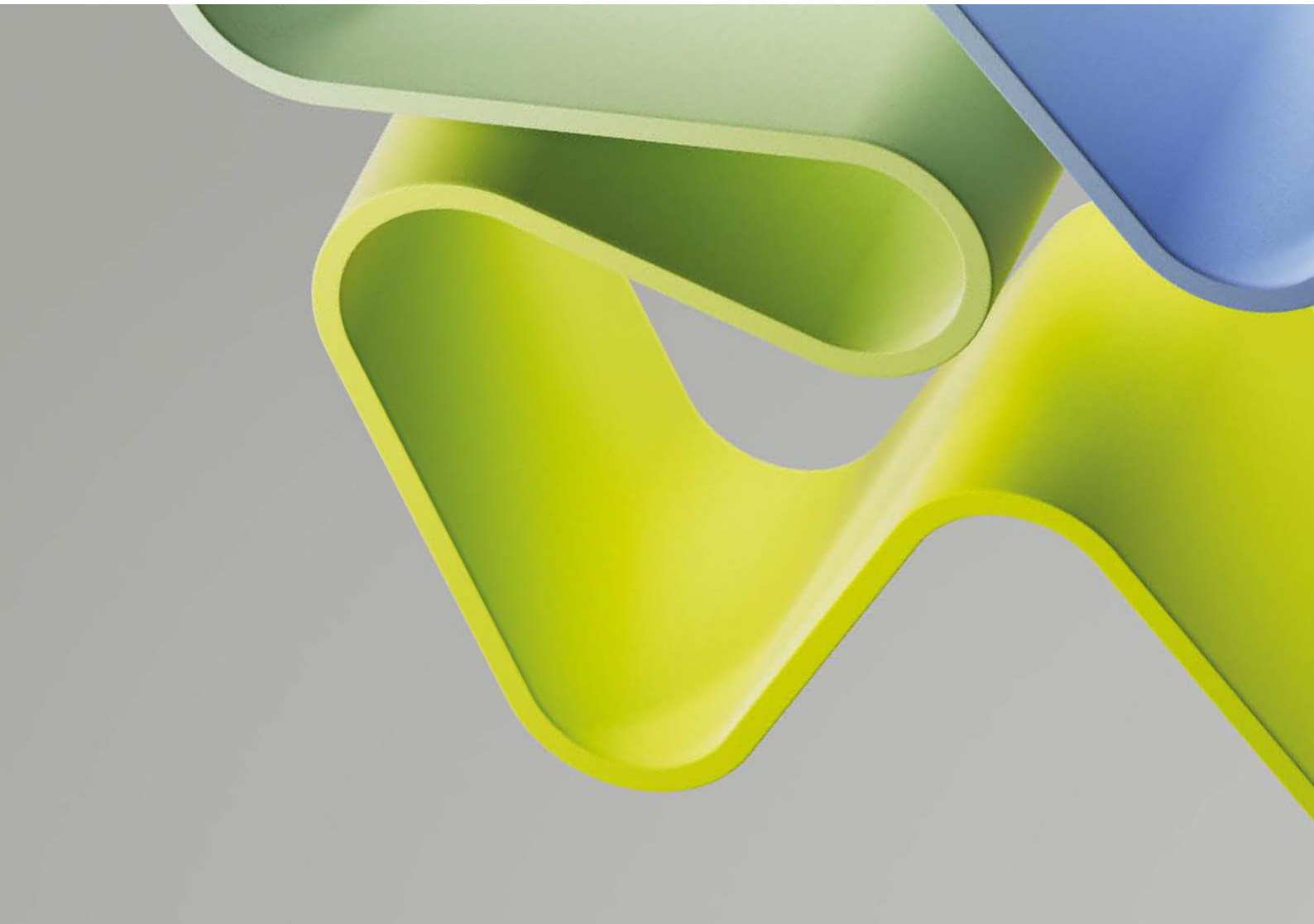
## Evaluation Report for Administrative Unit

Administrative Unit: **NORCE Energy and Technology**

Institution: **NORCE Norwegian Research Center (NORCE)**

Evaluation Committee Institutes

December 2024



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## Statement from Evaluation Committee Institutes

The members of this Evaluation Committee have evaluated the following administrative units at the research institutes within Mathematics, ICT and Technology 2023-2024 and has submitted a report for each administrative unit:

- NORCE Energy and Technology, NORCE Norwegian Research Center (NORCE)
- SINTEF Community, SINTEF Community
- SINTEF Digital, SINTEF Digital
- SINTEF Industry, SINTEF Industry
- SINTEF Energy, SINTEF Energy
- SINTEF Ocean, SINTEF Ocean
- SINTEF Manufacturing, SINTEF Manufacturing
- Norwegian Computing Center (NR), Norwegian Computing Center (NR)
- Energy and Energy Technology (ENET), Institute for Energy Technology (IFE)
- Simula Research Laboratory (SIMULA), Simula Research Laboratory (SIMULA)
- Human and organisational factors (HOF), Institute for Energy Technology (IFE)

The conclusions and recommendations in this report are based on information from the administrative units (self-assessment), digital meetings with representatives from the administrative units, bibliometric analysis and personnel statistics from the Nordic Institute for Studies of Innovation, Research, and Education (NIFU) and Statistics Norway (SSB), and selected data from the National survey for academic staff in Norwegian higher education and the National student survey (NOKUT). The digital interviews took place in the autumn 2024.

The members of the Evaluation Committee are in collective agreement with the assessments, conclusions and recommendations presented in this report. None of the committee members has declared any conflict of interest.

The Evaluation Committee consisted of the following members:

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## Description of the Administrative Unit

NORCE is a private nonprofit research institute that conducts research and innovation in the areas of energy, health, climate, environment, society, and technology. NORCE Energy & Technology (E&T) is a medium-sized admin unit comprised of four departments (Energy, Enabling Technologies, Observation Systems and Research Infrastructure) containing a total of 14 Research Groups.

The unit is engaged in research supporting exploitation and production of energy from multiple sources (fossil fuels to renewables), energy system integration and the energy transition, technology solutions for land-based industry and aquaculture, and development of space, air, land, and ocean observing systems, as well as more generic technology development and digital solutions for the benefit of the broader society. The Research Infrastructure Department consists of the Ullrigg Test Centre – a full-scale test and piloting centre for drilling and well activities.

The unit employs 242 research staff, 93 of which are Senior Researchers. More than 64% of research staff within NORCE E&T hold a PhD and 31% of the research staff are non-Norwegian. 80% of the E&T division staff are men and 20% are women

The management division of NORCE E&T includes the Division Leader, Department Leaders, Finance Controller, Strategic Advisors and Staff Coordinator. Each department is managed by the Department Leaders, and Research Groups within the Departments are led by Research Directors. Each Research Group has their own independent finance performance responsibility.

The objectives of the unit align with the overall objectives for NORCE to be a “driving force for positive and sustainable development through socially relevant research, dissemination and innovation”. E&T implement these objectives through their E&T Division Strategic Goals and Action Plan. In recent years, the unit has shifted their research portfolio to support the energy transition and sustainable technology development. The main strategic goals for research and innovation of the E&T Division, is “Be a visible and leading national and international player in energy and technology research, by further developing expertise, capacity and infrastructure within renewable and environmentally friendly energy and maintaining our strong position within petroleum (contributing to improved recovery with reduced emissions)” and “Utilize our core competence to grow into other market areas/domains”.

Shifting the research portfolio to support the energy transition and sustainable technology development in the society and applying for new key research infrastructure is a strategic priority for the E&T Division. To support this, the unit has recently increased the portfolio of EU projects, particularly within energy systems, geothermal, CCUS, and digital technologies.

The unit has strong connections with the universities that own NORCE, the Universities of Bergen, Stavanger, Agder and Tromsø, and hosts or participates in a range of national research centres including Centres for Research-based Innovation (DigiWells, SWIPA and Smart Ocean), Norwegian Centres of Expertise (Maritime Cleantech, Seafood Innovation, Energy Transition Norway, Norwegian Offshore Wind), the Centre for Sustainable Subsurface Resources, and the Global Centres of Expertise for Blue Maritime and Ocean technology.

The unit actively pursues collaboration also with industry and business clusters and is a core member of the innovation knowledge cluster for western Norway, Energiomstilling Vest (EOV), as well as a partner in Energy in the North, the Sustainable Energy Catapult and

Ocean Innovation Catapult. The unit has produced many successful spin offs, patenting and licencing initiatives, including as SEKAL, GexCon, Prototech and Offshore Sensing.

E&T identify several strengths and opportunities to better position themselves in the future. This includes their strong professional breadth allowing them to apply a holistic approach to problems, their unique drilling-rig infrastructure, strong use of digital technologies and balanced portfolio of contract research and international grants. They also note their increasing number of EU projects, their position within the petroleum industry in line with the Norwegian's state plans for development of their continental shelf and their position as industry favourite in regions where they have offices. In terms of weaknesses and threats, E&T note their limited network with industry in the green shift, insufficient interaction with RCN for influence of programs and calls for proposals and low level of basic funding. They also note geopolitical instability, change in framework conditions for core markets such as petroleum, reduction in government funding and lack of funding for the development of new infrastructure.

## Overall Assessment

The evaluation committee found the E&T Division to be a strong unit with a clear strategy aligned with the NORCE overarching strategy and with specific direction for the E&T Division. The division provided evidence of good progress and consideration of shifting the research focus and projects towards green transition. They described an effective approach to building research competence and providing opportunities for cross disciplinary research and working across research groups and divisions. There is evidence of growth in international research projects, following the strategic direction. The diversity within the research staff is low and the team discussed difficulties in recruitment. The division has 14 research groups of size ranging from 9 to 27 members, with different profiles in research projects, funding sources and level, and research excellence. Some of the research expertise is well-suited to green transition, but others are less so, and the division did not present clear strategy for redirecting competences. At the same, the division should include in its strategy plans to grow and reduce resources and review its composition and research group structure.

Strengths:

The Energy and Technology division has several leading research communities and individual researchers in future-oriented research topics. As part of NORCE, it has access to a strong professional breadth (social science, health, climate, environment, energy and technology) which enables research to be carried out in a holistic and interdisciplinary approach. E&T Division has world leading research within underground and drilling and wells. It hosts 3 RCN centres and is the main partner in several centres. It has a good national and international network within some core areas. It has unique software built over decades. It hosts unique infrastructures, like the full-scale drilling rig and the research airplane. It has good relations and trust with several major customers and high resale share, and project deliveries are generally of high quality. E&T Division is strong in the use of digital technologies as tools (AI, signal processing, big data analytics). It is represented in the important regional industrial clusters. Overall, the project portfolio has a good balance between contract research and national & international grants.

Weaknesses:

E&T division lacks network with new industry in the green shift and has limited strategic resource capacity to develop and win large internal investments. It has insufficient interaction with RCN and influence of programs/initiatives/calls for proposals. The application writing process should be improved, and too few applications to EnergiX (KSP and IPN) and the EU are submitted. The amount of basic funding is limited compared to universities and international research institutes. There is limited domain knowledge and customer network for some new technology areas. Some research groups have too many small projects, and within some areas, there are a limited number of researchers with good CVs.

There is a good opportunity to grow research strengths and projects in the green shift, skills are competencies are mostly well aligned for transfer into this sector, but networks need to be built. At the same, some strategical choices should be made to position more clearly within the green transition. Some companies that the E&T Division work with are also seeking to transition their activities to the green agenda and NORCE E&T should take a leading role to support the shift in research rather than waiting to follow the industry.

There are opportunities to increase the number of strategic partnerships (national and international) and utilise the centres to develop the project portfolio within the scope of the centres. Norway's commitment to digitalisation and artificial intelligence is an opportunity to

increase the project portfolio within digital technologies. Focus on space industry, knowledge centre for earth observation activities, ocean industries and transport, services to the public sector. NORCE E&T Division can become the industry's preferred partner in regions using the industry clusters in the region, NORCE regional managers and NORCE regional councils. Recruitment of strategic project development expertise will help to increase the EU portfolio and industry-financed projects.

The table below addresses each of the questions raised by the admin unit in the Terms of Reference (ToR) for the evaluation.

*Table 1 Evaluation Committee response to specific questions from the ToR*

| **Specific request from the ToR** | **Evaluation** |
|---|---|
| The Technology division has several strategic initiatives. Have we chosen the right ones, and do we have sufficient/right resources to win the competition for the major projects/centres nationally/internationally? Are we appropriately organised to support our strategic initiatives? | Reflection on the research strategy and recommendations from the committee are given in Section 1.1. |
| The Technology division is hosting/participating in several centres. To what extent do we take advantage of this position? | Reflection and recommendations from the committee are given in Section 1.6. It is recommended for continue to invest in competence building centres and training PhDs in collaboration with end users |
| A large proportion of the groups in the division have long experience with research projects related to the petroleum industry and are internationally recognized in their fields. The strategy is to “Be a visible and leading national and international player in energy research by further developing expertise, capacity and infrastructure within environment-friendly energy and consolidating our strong position within petroleum (contributing to improved recovery with reduced emissions)”. To what extent have we succeeded in shifting to renewable and sustainable energy research? | Recommendations on the green shift are given throughout the report. The unit is encouraged to provide a record of funding secured related to the petroleum industry and to the green shift in order to monitor the transition.<br>The unit should consider taking more of a leadership role in setting agenda for innovation and research, and support industry partners in the green transition. It can define more clearly strengths and niche areas within the green transition. It is encouraged to reflect on measures taken to improve success in winning international research grants and in diversifying portfolio, and to enable the increase in research funding to affect the shift in portfolio towards green energy transition. |
| NORCE Technology have international leading research in several fields, to what extent do we succeed in utilize this advantage? | Comments are given on the international reach, positioning and success are given throughout the report, and in particular in Section 1.1. |
| NORCE has a wide range of expertise in the three divisions: Health and Social science, Climate and Environment, and Technology. This gives us the potential to create inter and multidisciplinary projects that address major societal challenges. To what extent have we succeeded in this? | It is not clear to the evaluation committee from the information provided in the self-assessment and the interview the extent to which the organisational structure of the admin unit enables researchers to meet and form interdisciplinary teams with other NORCE divisions. It is therefore recommended that the NORCE strategy should be developed to enable an interdisciplinary approach to societal challenges, and to encourage and maintain thematic research meetings to enable researchers to meet and inter-disciplinary teams to form. |
| Our infrastructure is extensive. Does the infrastructure support our research activities and enhance our competitiveness? | The committee recognised the strength of the infrastructure and facilities and that access to the facilities makes NORCE an attractive |

| | |
|---|---|
| | collaboration partner. The unit is encouraged to seek further opportunities to build collaborations with industry through use of the infrastructure and facilities, and further opportunities to utilise the facilities for research and innovation in energy transition. |
| How can we exploit the possibilities for EU funding in a better way? | The application writing process should be improved, and more applications submitted to the EU. |
| Does our research impact the wider society and businesses, including innovations and commercialization of results? | This is addressed in sections 4 and 5 of this report. |

*The Terms of Reference for the administrative unit is attached to the report.*

## Recommendations

1. Develop quantified success criteria to measure the progress against the strategy of the division, with monitoring on a regular basis. Success criteria, such as funding balance between public and private, publications, international collaboration, university collaboration, should be defined relative to benchmark from defined comparator set of institutes.
2. Strategy should enable an interdisciplinary approach to societal challenges
3. Strategy for international engagement and positioning in new areas Hydrogen and Offshore Wind
4. Consider taking more of a leadership role in setting agenda for innovation and research, and support industry partners in the green transition.
5. Consider defining more clearly strengths and niche areas within the green transition
6. Encourage and maintain thematic research meetings to enable researchers to meet and inter-disciplinary teams to form.
7. Reflect on measures taken to improve success in winning international research grants and in diversifying portfolio. Is the success throughout the division or can it be improved in some areas using the same approach?
8. Develop strategy to enable the increase in research funding to affect the shift in portfolio towards green energy transition.
9. Seek further opportunities to build collaborations with industry through use of the infrastructure and facilities that the E&T Division host.
10. Seek further opportunities to utilise the facilities for research and innovation in energy transition.
11. Increase diversity and lower age profile of teams for sustainability and succession, measure and monitor impact of actions taken.
12. Research staff have strong competency that is transferrable to the new energy transition research strategic direction, but retraining for new applications should be considered
13. Internal funds should be set aside for conferences and research visits to build networks and competence
14. Continue to invest in competence building centres, SFI and SME, training PhDs in collaboration with end users

15. Consider how to raise awareness of stakeholders and external users of the open data and research papers
16. Consider progress monitoring to check all publications are uploaded to open portals.
17. Quantified Impact metrics should be tracked and provided to demonstrate the impact of research on industry and society.

# 1. Strategy, Resources, and Organisation of Research

NORCE is a research institute, founded in 2017, and is part of the Norwegian research institute sector, where the purpose is to undertake applied research and offer expertise and services in fields that are relevant to Norwegian business, public governance and/or society. NORCE qualifies for receiving public basic funding administered by the research Council of Norway.

The E&T Division is engaged in research supporting exploitation and production of energy from multiple sources (fossil fuels to renewables), energy system integration and the energy transition, technology solutions for land-based industry and aquaculture, development of space, air, land, and ocean observing systems, as well as more generic technology development and digital solutions for the benefit of the broader society.

As part of NORCE, it has access to a strong professional breadth (social science, health, climate, environment, energy and technology) which enables research to be carried out in a holistic and interdisciplinary approach.

Shifting the research portfolio to support the energy transition and sustainable technology development in society and applying for new key research infrastructure (physical and digital) is a strategic priority for the E&T Division.

Basic funding is provided at both divisional and corporate level to develop such initiatives, and in funding from RCN. The E&T division hosts or participates in several new long-term centres for research and innovation with university partners, such as RCN-funded SFI DigiWells, SFI SWIPA, SFI Smart Ocean, Petrocentre CSSR, Petrocentre NCS2030, and FME HyValue. This exceeds ambitions set in 2019 strategy for the division, which included hosting or become a major partner in at least three new long-term centres.

Grants received for the OpenLab drilling infrastructure and portfolio of EU projects in increased, especially within energy systems, geothermal, CCUS, and digital technologies. Through this diverse portfolio and collaborative partnerships, the E&T portfolio has shifted from a strong dependence on oil & gas related projects to a more diverse portfolio, which was also a strategic goal in 2019. It was described in the interview that previously, oil and gas sector projects accounted for 95% of E&T division activities, and in recent years this has reduced to 70%.

There are good examples of actions taken to strengthen industrial collaboration and stimulate innovation, such as establishing industrial funding for innovation activities, P&A innovation program and DigiWells innovation program and long-term centres and thereby shifting the project portfolio to include more Innovation projects for industry (IPN) and Demo projects.

### 1.1 Research Strategy

The Energy & Technology (E&T) Division follows the overall NORCE 2022-2025 Strategy where the overall objective is “NORCE will be a driving force for positive and sustainable development through socially relevant research, dissemination, and innovation”. The main

objective set in the NORCE 2022-2025 Strategy for Research and innovation is “NORCE will be a national leader and internationally recognised research institute”.

The E&T Division, in collaboration with the NORCE Climate & Environmental and Health & Social Science Divisions, has a broad range of competencies. These should enable an interdisciplinary approach to societal challenges.

There are four priority areas where all three divisions contribute: Safe and Welcoming Societies, Climate and Environmental Risks, Sustainable Seas and Coasts, and Energy of the Future. NORCE has allocated basic funding to support competence building and project development for these cross-cutting areas.

Based on this overarching strategy, the E&T Division Strategic Goals and Action Plan guides the organisation, strategic research initiatives, commercialisation, external engagement, and dissemination, as well as policy and societal impact. The goal is to provide relevant knowledge, innovative technologies and solutions to industry and public sector at all TRL levels. The strategy of the unit is therefore in clear alignment with the NORCE overarching strategy, though with a specific direction for the E&T admin unit.

The main strategic goals for research and innovation of the E&T Division, is to “Be a visible and leading national and international player in energy and technology research, by further developing expertise, capacity and infrastructure within renewable and environmentally friendly energy and maintaining our strong position within petroleum (contributing to improved recovery with reduced emissions) “. Further “Utilize our core competence to grow into other market areas/domains “. These goals are also in alignment with the objectives of the NORCE institution.

The self-assessment reports for the unit did not provide any clear criteria or measures for monitoring progress or success. This should be developed and implemented and include key measures such as funding balance between public and private, publications, international collaboration, university collaboration, etc. The admin unit should also seek to benchmark their activities against a defined comparator set of measures or institutes.

According to research group reports, the overall strategy is followed in research groups to varying degrees. Some are lacking focus and direction in the transition to net zero topics. For example, Hydrogen and Offshore Wind are mentioned in many of the research group reports as target areas, but a local and specific strategy for international engagement and positioning in these topics was not evident from the documents provided in the self-assessment report for the admin unit. The admin unit will therefore need to set a clear strategy for redirecting and developing the competences in its research groups in key areas and for setting a strategy for international engagement and positioning in new areas.

NORCE has allocated basic funding to support competence building and project development for these cross-cutting areas across divisions. The E&T division are effectively shifting their portfolio to increase collaboration with industry, and to encourage the shift to green transition research areas. There is an established structure for feeding into the overarching strategy from across the division, and clear routes for dissemination into the research group level as explained during the interview with the team. Management meetings at division head and management group levels enable sharing of best practice within the organisation. Opportunities for cross-disciplinary working and working across research groups and divisions are enabled through regular thematic meetings. Overall, the evaluation committee consider this to be an effective approach for building competence and for providing opportunities for cross disciplinary research and working across research groups and divisions.

Recommendations to the administrative unit.

- Develop quantified success criteria to measure progress against the strategy of the admin unit, with monitoring on a regular basis. Success criteria, such as funding balance between public and private, publications, international collaboration, university collaboration, should be defined relative to a benchmark from a defined comparator set of institutes.
- Strategy should enable an interdisciplinary approach to societal challenges
- Strategy for international engagement and positioning in new areas of Hydrogen and Offshore Wind
- Consider taking more of a leadership role in setting the agenda for innovation and research, and support industry partners in the green transition.
- Consider defining more clearly strengths and niche areas within the green transition
- Growth/restructure/competence transformation strategy?
- Gender balance/diversity – measure and actions and impact
- Excellence of research – status and actions and impact

### 1.2 Organisation of Research

The E&T Division was first organised in two departments, Energy and Technology. In January 2022, the company structure was adapted to promote a more holistic and transdisciplinary approach - integrating six departments into three divisions, one of them being the NORCE E&T division. The NORCE E&T Division is organised into four departments; three departments with a total of 14 research groups and one department that is solely an infrastructure unit. The Division management includes the Division leader, Department leaders, Finance controller, Strategic advisors, and a Staff Coordinator. Each department is managed by Department leaders, whereas the research groups are led by Research Directors.

What is not clear to the evaluation committee is the extent to which this structure enables researchers to meet and form interdisciplinary teams with other NORCE divisions. Beyond the E&T Division, the admin unit could have some competitive edge in cross-cutting topics especially together with social sciences, as this aspect is currently lacking for green transition generally, and there would be need for proper social dimension. In future, the admin unit should consider how to encourage and support such collaborations.

The research groups have finance performance responsibility and are independently accountable for developing their research portfolios and scientific staff according to the overall division goals.

Recommendations to the administrative unit.

- Encourage and maintain thematic research meetings to enable researchers to meet and inter-disciplinary teams to form.
- Consider looking more at social aspects of green transition together with other divisions within NORCE

### 1.3 Research Funding

The E&T division is funded through a diverse portfolio of funding sources. NORCE is a private nonprofit research institute with around 10% public basic funding. The remaining 90% of funding comes from grants and contracts exposed to competition. The revenue

includes 51% national and international grant funding (NFR and EU) and 49% contract research (public and private sectors). The admin unit total yearly budget (2022) was 453 MNOK of which 355 MNOK are research hours and 98 MNOK project expenses.

The amount of basic funding however is limited compared to universities and international research institutes.

According to the self-assessment report, there is increase in funding success rate through expansion of existing and addition of multiple new funding streams. This includes grants and contracts related to shifting the research portfolio to support the energy transition and sustainable technology development in society. Increased success in winning bids for national research centres (SFI, FME, Petrocentres) has added significantly to division's long-term funding. They have also experienced increased success in winning EU proposals, which contributes to strengthening international funding streams. This is commendable and should be continued to enable the admin unit to meet its objectives.

As noted above, the E&T portfolio has sought to reduce its dependence on the oil and gas sector and has reduced the proportion of projects from 95% of E&T division activities to 70%. This is also commendable and should be continued.

As the unit has clear need for transforming some competencies towards green transition, it will be of utmost importance to assure some research funding that allows this in an adequate scale. To support this, the admin unit could benefit from a clear strategy and approach, specifically for securing funding to align with this objective. The admin unit could take lessons learnt from its previous success and apply them across the division to ensure the unit is securing a diverse portfolio of projects that align with its longer-term objectives.

Recommendations to the administrative unit.

- Reflect on measures taken to improve success in winning international research grants and in diversifying portfolio. Is the success throughout the division or can it be improved in some areas using the same approach?
- Develop strategy to enable the increase in research funding to enable the shift in competencies and portfolio towards green energy transition.

### 1.4 Research Infrastructures

The E&T Division host two national infrastructures are partners in four and user in two.

The OpenLab Drilling hosted by E&T division is a national research infrastructure for research and technology development within drilling and well operations. The applications include drilling and well operations for petroleum production, CO2 storage, hydrogen storage, and mineral mining. The simulator is available as physical infrastructure environment at NORCE location in Stavanger and on the internet.

The E&T Division also hosts the Ullrigg Test Center, UTC, which is listed on the Norwegian Roadmap for research and is a full-scale test and piloting centre for technology, systems, methods, and solutions in drilling and well activities. UTC is a full-scale offshore drilling unit, constructed and enhanced through 40 years together with industry, led by industry and R&D needs supported and funded by both the industry and private sector.

E&T Division is a partner in the Norwegian P&A Laboratories, a national Plugging and Abandonment (P&A) infrastructure being established at NORCE, SINTEF, UiS and NTNU, with financing from RCN. It is also partner in SIOS Infranor, which is an international infrastructure and coordination project to develop and coordinate the scientific infrastructure

on Svalbard. The goal of the infrastructure is to monitor impacts of climate change and understanding of how the change affects the arctic environment and its ecosystems. E&T Division is a partner in the TONe, Troll Observing Network, which comprises observatories and services to enable environmental research and understanding of the role of eastern Antarctica in the climate system, and how climate change will impact fauna and primary production. It is partner in EPOS-N and responsible for the e-Infrastructure portal that integrates data from existing Norwegian research infrastructures in solid earth science. It is a web-based software to visualise, sort and analyse different types of geoscientific data, volcanic eruptions, slope instabilities, tsunamis, tectonics and Earth surface dynamics.

In addition, E&T is a frequent user of the ECCSEL Infrastructure, Svelvik CO2 Field Lab, for testing of DAS for monitoring in relation to CO2 injection and storage. E&T Division also uses NIRD both for access to High-Performance Computing and large-scale data storage.

Within international infrastructures, NORCE has a long track record in radar satellite remote sensing and are selected by ESA as an Expert Support Laboratory for the Envisat and Sentinel-1 missions, part of the Copernicus satellite infrastructure. Norwegian membership in the Copernicus program is at the core of the satellite remote sensing activities at NORCE, and a critical infrastructure for the satellite research activities and service development.

E&T use the ESFRI: European Next Generation Incoherent Scatter radar infrastructure to develop a space debris tracking system. They use the European Multidisciplinary Seafloor and water column Observatory in the HORIZON-INFRA project George (2023- 2027), which brings together expertise from three ERICS, EMSO, ARGO and ICOS to develop next generation tools and platforms aimed at assessing the role of the ocean in taking up CO2 from the atmosphere in a changing climate. NORCE is responsible for developing and maintaining parts of the core services for the eInfrastructure of the European Plate Observing System, including the Enlighten Web tool for interactive analysis of data. As part of the Svalbard Integrated Arctic Earth Observing System, E&T is responsible for the Aircraft infrastructure, and SAR satellite snow products.

Recommendations to administrative unit.

- Seek further opportunities to build collaborations with industry through use of the infrastructure and facilities that the E&T Division hosts.
- Seek further opportunities to utilise the facilities for research and innovation in energy transition.

### 1.5 National and international collaboration

The E&T division have significant European international collaborations and strong national collaborations with HEIs and industry. A particularly important vehicle for collaboration is the Energiomstilling Vest (EOV), a knowledge cluster including in addition to NORCE, the University of Bergen (UiB), University of Stavanger (UiS), Western Norway University of Applied Sciences (HVL) and Norwegian School of Economics (NHH). EOV aims to strengthen the cooperation between the R&D communities, businesses, industry clusters and public sector in Western Norway, targeting businesses, policymakers, public management, and society at large to support the energy transition. The FME HyValue is a result of this collaboration.

Staff collaborate with many national universities and research institutes, but university owners of NORCE: UiB, UiS, UiA and UiT, are considered the most important collaborations. These have established collaboration agreements and regular meetings at a strategic management level to discuss priorities and opportunities for collaboration. Calls for national

research centres such as SFIs and FMEs have high priority and partners mutually invite each other into the consortia as appropriate.

The E&T division actively pursues collaboration with industry and business clusters and catapults, such as GCE Blue Maritime Cluster, GCE Node, GCE Ocean technology, NCE Maritime Cleantech, NCE Seafood Innovation, NIC Energy Transition Norway, NIC Norwegian Offshore Wind Cluster, Sustainable Energy Catapult and Ocean Innovation Catapult, METCentre, Energy in the North. NORCE provides candidates for the board in several of these clusters and participates in events and workshops facilitated by the clusters to learn about challenges and priorities within the business areas they represent. These meetings are effective for identification of opportunities for collaboration and facilitation of project ideas that can be developed into research proposals.

Internationally the E&T Division has a large academic network and collaboration, engaging in European networks, like EU Robotics, CO2GeoNet, and Joint Program EERA to influence research policy on European level and to find good strategic partners for future EU calls. NORCE also participates in ESA working groups to influence new satellite missions in the explorer programs and Copernicus services. E&T is involved in many HEU projects and maintain these networks through initiatives for new projects.

What is less clear to the evaluation committee is the extent to which the admin unit has collaborations and networks in areas relating to its longer-term strategic objectives around net zero. E&T division currently lacks network with new industry in the green shift and has limited strategic resource capacity to develop and win large internal investments. The unit should therefore develop and implement a plan for developing strategy collaborations in new areas of focus to build domain knowledge and access to customers for new technology areas.

Recommendations to administrative unit.

- Develop strategic collaborations in new areas of focus, i.e. in energy transition and renewable energy
- Enable more placements and exchanges (short and more extended visits) for researchers to build competence in new research directions

### 1.6 Research staff

Most of the scientific staff at the E&T Division are trained in mathematics, physics, or informatics, with skills that are applied in a variety of thematic areas. The basic skill in natural sciences makes the division workforce flexible and adaptive to thematic changes in the research portfolio. In addition, engineers and technicians are critical in many of the technology innovation projects as well as for operating and running the research infrastructure.

Some of the research staff have strong competency that is transferrable to the new energy transition research strategic direction. To ensure the admin unit has access to all the necessary expertise and skills needed to realise its longer-term objectives, they should also ensure there are mechanisms for retraining existing staff in new areas.

The admin unit has fairly good international diversity. Currently, more than 64% of the research staff in the E&T division hold a PhD and 31% of the research staff are non-Norwegian. In total, 69% of researchers are from Norway, 2% from other Nordic countries, 18% from other EU countries and 11% from non-EU countries.

The gender diversity of the admin unit is less good overall. There is a good balance of gender at the management levels - the E&T division management team consists of four men and three women (43%), 43% of the Research Directors are also women. However, the balance is less good across the wider team of researchers. The percentage of females is 20% of E&T staff. This is too low, and the admin unit should put in place specific measures to improve this. In the interview, the admin unit partially attributed the poor gender balance to difficulties in recruitment. The evaluation committee appreciate the challenges of recruiting in this area and recommend the admin unit explore alternative routes for attracting, training and retaining female researchers rather than relying on recruitment and the market.

Administrative staff are organised in other units and not included in E&T Division's figures provided for the evaluation.

The distribution of research time is somewhat different for the various researcher categories. A researcher is expected to do research, write applications, interact with industry and partners to develop projects and competence. I.e., the expectation for a research director typically is roughly 30% on research, 30% personnel leadership, 40% interaction with industry and market development.

A chief scientist will typically spend 60% on research and 40% on project development/applications/market. For a senior researcher, the expectations are approx. 70% on research and 20% on project development/applications and 10% on interaction with market and customers. A Junior scientist is expected to spend more on research and less on acquisitions and development.

Most of the basic funding is distributed to the research groups, either directly or through support of strategic initiatives and can therefore provide support for more "free" research to support the strategy. The Norwegian research institute sector (and NORCE) does not have public basic funding to allow regular leave/sabbatical as an option for staff. Mobility for researchers therefore needs to be funded by research grants and contracts. Such activities are however essential for building networks and competence, especially in new areas, and can also support recruitment activities.

The NORCE E&T Division supports researcher mobility through projects, hosting guest researchers and interns for extended visits from its international network of partners. NORCE researchers can apply for research grants for research visits to foreign collaborating institutions, but this is not common. Early career researchers can apply for mobility grants through NFR programs, but these only support extra costs of living abroad, so the researcher depends on having salaries covered elsewhere. Fulbright Scholarships are also an opportunity in collaboration with US institutions. PhD students and Post Doc's usually have mobility support for research stays up to 12 months included in their NFR grants, or they can apply for EU MSCA grants. Whilst there a breadth of opportunities available, these largely seem to depend on NORCE researchers securing specific grants. To ensure the admin unit is not depending too much on individual team members securing such grants, E&T should therefore seek to set aside internal funds for such activities.

<u>Recommendations</u> to the administrative unit

- Increase diversity and lower age profile of teams for sustainability and succession.
- Put in place measures and systems to monitor impact of actions taken to improve diversity and balance of staff

- Research staff have strong competency that is transferrable to the new energy transition research strategic direction, but retraining for new applications should be considered
- Internal funds should be set aside for conferences and research visits to build networks and competence
- Continue to invest in competence building centres, SFI and SME, training PhDs in collaboration with end users

### 1.7 Open Science

E&T Division follows the NORCE overarching strategy for open science. Researchers are contractually obliged and comply with Open Access (OA) requirements set out by the NFR and EU and follow the principles of Plan S and the FAIR principles. Researchers upload all scientific publications and other outreach in the national database Cristin. The division provides OA code through Git Hub. In 2022, 77% of the NORCE E&T Division publications were published in OA journals, and staff are encouraged to volunteer as reviewers in OA journals with open peer review. However, according to the metrics gathered for the evaluation committee, of the 138 research publications published by the division in 2022, 46% were not OA; 23% gold access and 31% archived. Overall, the approach to open science is good, but the data should be checked and accurately presented.

Observational data is shared through portals and data catalogues such as SIOS and INTAROS where the data is stored at NIRD and Zenodo, data is shared with stakeholders/user groups in almost all projects. Citizen science is included in some projects through collaboration with social scientists at NORCE, in particular where new technology/infrastructure is implemented in society, such as CO2 storage, offshore wind and hydrogen for use in the transport sector.

Researchers must comply with the principles and recommendations in the NORCE governance system MAPS, including preparation of project contractual agreements that regulate the development and implementation of data management plans and rules for confidentiality. The scientists own the data they produce, but in some projects, restrictions on publication and confidentiality must be considered. The sharing of research data is based on the principle “Open as possible, closed as necessary”. In general data produced in the division is open and made available in open repositories, adhering to the principles of making research data findable, accessible, interoperable, and reusable (FAIR).

It was not clear to the evaluation committee based on the self-assessment report, if the admin unit takes any measures to raise awareness of their research outputs (publications and data) amongst wider stakeholders and potential users.

<u>Recommendations</u> on how to promote open science

- Consider how to raise awareness of stakeholders and external users of the open data and research papers
- Consider progress monitoring to check all publications are uploaded to open portals and check that data on open access publications is accurately reported.

## 2. Research production, quality and integrity

The E&T division carries out research and technology development to support sustainable exploitation and management of natural resources. Specifically, to generate knowledge necessary for the green energy transition and societal transformation towards a sustainable future. This includes reducing the carbon footprint in energy and industrial production, reducing waste by increasing remanufacturing and circular economy, and increasing the ability of public administration to regulate and secure sustainable growth. The E&T division develops solutions for:

- Increased understanding and digital solutions of subsurface resource utilization.
- Methodologies for processing and interpretation of multiple, multimodal and multitemporal physics data for monitoring the subsurface.
- Safe and cost-efficient drilling and well operations with minimum environmental footprint for petroleum production, CO2 injection and geothermal energy.
- Plugging and abandonment of wells.
- Improved sensors and observing systems to enable increased resolution and more cost-effective data acquisition.
- Automation and robotic solutions for more effective industrial production and operations.
- Data processing, assimilation and optimisation methodology for better analysis and interpretation of (large) data volumes.
- Experimental studies and testing to characterise flow in subsurface reservoirs and behaviour of drilling operations.
- Managing and predicting geohazards such as land and rockslides, snow avalanches, extreme weather, and flooding by remote sensing data analysis.
- Detection and quantification of marine and terrestrial resources, supporting sustainable resource exploitation.
- Safe navigation in coastal and arctic areas through wave and current modelling, sea ice mapping and drift estimation.
- Space situational awareness, space object detection and tracking.
- AI, digitalisation, and predictive maintenance in several application areas.
- Flow measurement, fluid dynamics and uncertainty calculations of flow and emissions.
- Measurement systems tailored to specific applications based upon electromagnetic, acoustic, and optical (DxS) technologies.
- Process modelling, system simulation and data analysis.
- Integrated energy systems, energy efficiency including geothermal energy system

E&T Division is strong in the use of digital technologies as tools (AI, signal processing, big data analytics).

In 2022, the admin unit published 138 papers, which was far lower than the benchmark (the average of all admin units submitted for evaluations under EVALMIT). The proportion of papers in the 10% most cited publications between 2019 and 2021 was also lower than the benchmark (6.3% compared to 10.4%). The rate of international co-publication is good (52.9%) which is line with the benchmark of other EVALMIT admin units (53.8%). The admin

unit is however not supporting hugely interdisciplinary research, as indicated by the bibliometric analysis which presents an interdisciplinarity score far lower than the benchmark of other admin units (172 vs 529).

The research strategy should consider the balance between small and large project proposals and support the development of larger research grant proposals.

There is a good opportunity to grow research strengths and projects in the green shift, skills are competencies are mostly well aligned for transfer into this sector, but networks need to be built. At the same, some strategical choices should be made to position more clearly within the green transition. Some companies that the E&T Division work with are also seeking to transition their activities to the green agenda and NORCE E&T should take a leading role to support the shift in research rather than waiting to follow the industry. The admin unit's approach to ensuring research integrity is appropriate with a focus on peer reviewed publications and open access platforms. The unit is encouraged to grow strategic project development expertise to help with proposal writing and to increase success in securing larger grants. This will help to increase the RCN success rate as well as the EU portfolio and industry-financed projects. The research groups should continue to give staff the opportunities to develop their research expertise and grow the portfolio of projects, external collaborations and research outputs.

### 2.1 Research quality and integrity

Overall, the evaluation committee found that the admin unit has several leading research communities and individual researchers in future-oriented research topics. The E&T Division has world-leading research within underground drilling and wells.

Some of the research expertise is well-suited to green transition, but others are less so, and the division did not present a clear strategy for redirecting competencies.

The E&T Division has strong networks nationally and internationally and hosts important infrastructures for the research and innovation community and is represented in regional industrial clusters. The overall project portfolio is well balanced between contract research and national & international grants. However, the interaction with RCN could be strengthened and the committee recommends that the units give specific focus to improving the grant application writing process in order to increase the number of applications submitted and their success rate.

There are opportunities to increase the number of strategic partnerships (national and international) and utilise the centres to develop the project portfolio within the scope of the centres. Norway's commitment to digitalisation and artificial intelligence is an opportunity to increase the project portfolio within digital technologies. Focus on space industry, knowledge centre for earth observation activities, ocean industries, transport, and services to the public sector will enable the unit to become the industry's preferred partner in regions.

**Research group Modelling and Simulation (ModSim) overall assessment**

The research group is mainly contributing to NORCE's focus area of Future Energy. The group fulfils an important part of NORCE's mission. It contributes with competence in applied mathematics and finite element modelling related to Computational fluid dynamics (CFD). The applications are towards metallurgy (metal processes), geo-energy and energy systems. They have a close collaboration with local metallurgical industry. They attract both internal and external funding (mostly from Industry). The group seems to perform well considering the small size and considering their benchmarks. The research quality is perhaps not that

high in an international context, but they are also a rather unique entity. There is a minor but growing activity in biotechnology, based on expertise in computational fluid dynamics and heat transfer, extending also to a project for algae. One weakness of the group is its small size. However, there are plans to grow in size. They have a strong user involvement in their work. The societal contribution is good, but not great. They have for example developed software for industry and they are visible in media. Their contribution towards borehole thermal energy storage is very promising.

**Research group Coastal and Ocean Systems (COS) overall assessment**

The Coastal and Ocean Systems research group demonstrates notable strengths in advancing scientific knowledge, fostering societal impact, and engaging stakeholders effectively. With a focus on economic efficiency, safety enhancement, and environmental sustainability in maritime operations, the group has established itself as a key player in marine research within Norway. The group benefits from access to state-of-the-art research infrastructure and facilities, enabling high-quality research outputs. Through user-oriented publications and products, such as high-resolution coastal forecasts and data archives, the group has made significant contributions to maritime safety and operational efficiency, benefiting a wide range of stakeholders. Active engagement with industry partners has facilitated technology transfer and innovation, aligning research activities with real-world needs and priorities. While the group has made strides in national impact, its international engagement remains relatively limited, presenting opportunities for expansion and knowledge exchange on a global scale. The group's gender balance, particularly in leadership positions, requires attention to foster diversity and inclusivity within the research community. Overall, the Coastal and Ocean Systems research group is well-positioned to achieve its goals and continue making meaningful contributions to marine research and societal development. By addressing weaknesses, such as enhancing international collaborations and promoting gender diversity, the group can further strengthen its impact and reputation on both national and international levels.

**Research group Autonomous Systems and IoT (IoT) overall assessment**

Their expertise covers hardware/software development for smart sensors, sensor networks, and system integration, focusing on marine platforms, process industry solutions, and public infrastructure systems. The group's scope is well-defined but lacks PhD theses and clear numbers on master's thesis supervision. Industry cooperation is a highlight, though scientific dissemination and benchmarks need improvement. Although the group provides relevant benchmarks for the activities related to applied research, it lacks concrete plans and quality measures regarding scientific publications. Funding is robust from industry and the Research Council of Norway, but international funding is low. The group uses infrastructures like the Norwegian Ocean Laboratory, with adequate support from their host institution. Scientific contributions to advance the state of the art are modest with limited impact. Research quality shows modest contributions with a focus on engineering developments. National and international collaborations are notable, mainly with industry and in interdisciplinary research. Societal contributions include patents, start-ups, and some teaching, involving non-academic partners in the research process. Knowledge transfer has been very good.

**Research group Data, AI, Robotics, Vision, Visualization, Immersion (DARWIN) overall assessment**

Overall, DARWIN is a group that attracts substantial third-party funding and contributes to internationally relevant as well as visible research. Members of DARWIN have authored a considerable number of publications in international outlets of high reputation, especially

regarding fundamental AI. DARWIN is engaged in multiple successful collaborations with partners at universities and in industry. The collaborations with universities are particularly important for DARWIN to attract new and well-educated staff and, thereby, keep up a permanent inflow of up-to-date knowledge. This is most crucial in view of the high speed at which artificial intelligence is developing. A weakness is the self-assessment's lack of explanation for the merger of two groups over a very large distance. Also, it is not entirely clear which role the adjunct positions play for DARWIN. Regarding the topics of the publications, a gap can be seen between very theoretical and very applied contributions. These two aspects are both valuable, but it would be good to see more clearly how they benefit from each other.

**Research group Air and Space overall assessment**

The NORCE Air and Space Observing Systems research group (now two groups, of which one is on earth observations, and one is one drone operations) is mainly located in Tromsø. It consists of 25 scientists, primarily senior scientists with a PhD degree, and three engineers. Approximately half of the space-related projects are internationally funded, with the ESA and the EEA being the most important ones. The focus of the research activities in earth observations is on SAR monitoring systems for snow cover, avalanche detection, forest/land cover, polar low detection, flood, sea ice, ocean, intertidal zone, and geo-hazard monitoring. The second new group is experts in advanced drone operations. The research group has a very good strategy in terms of clear sub-goals and objectives. NORCE provides good support in terms of overall strategic goals on monitoring climate and environmental risks. The research activities in SAR applications including remote sensing software are very relevant for the organisation, and in connection to the Northern Norway location. It has also very good collaborations connected to European research programs. The drone operations in the arctic seem more high risk, but the self-assessment argues for a future need of professional drones for scientific data collection missions, and a manned aircraft has recently been acquired. The publication list in the self-assessment report contains some very good publications and some project overviews. The challenge is the focus on data collection with applications, but at the same time, this is the strength of the group. The group makes very good scientific contributions and is an important international partner. The area of the research is highly important for a sustainable society and is particularly relevant for the Polar Regions. This is a strength of the group. At the same time, the focus on data collection makes the group more like a sub-contractor in larger projects. User involvement and collaboration are strengths of the research group. The conclusions from the Expert Panel are:

- The NORCE environment that is adequate for supporting the production of excellent research.
- The research is clearly of an international standard, with a very good level of quality in terms of originality, significance, and rigor.
- The contributions of the research group to economic and societal development in Norway and international are very considerable given what is expected from groups in the same research field and organisations.
- The research group has played a considerable role in the research process from the formulation of the research problems and objectives goals to the publication and software development. The group could be highlighted in the evaluation's national assessment of the area.

**Research group Measurement Science overall assessment**

This is a well-established and experienced group which follows well defined goals and objectives in line with those at institutional level. It uses appropriately benchmarks to measure success and demonstrates good practice in managing the operations expected in a research institution of the size and quality of NORCE. It has built solid expertise in proven national and international areas of interest and is well-funded from sources in both areas. The business model is tested and proven successful through the years before and after the merger in 2018. It is tuned well to respond to the evolving landscape and particularly to the role of an intermediary between academia and industry, with a well-developed societal presence. There are no obvious disbalances and discrepancies across the three dimensions or the individual criteria used in this assessment exercise. The group is visible internationally, as evidenced by the submitted lists of projects and publications, as well as access to facilities. There is reasonable potential to enhance the international engagement in a bi-directional manner by considering additional strategies for dissemination of expertise capabilities and by continuing diversification. It may not be yet possible to assert the long-term impact of the merger in 2018, but the performance is strong since 2019, when normal work was resumed. The group self-certifies its working environment as being positive and supportive. The group finds it critical to mitigate the general tendency of lacking suitable candidates for scientific positions as well as transfer to academia and industry. It is unclear whether this is caused by the deficit of suitable skills or by lack of incentives. Such analysis and conclusions may help towards working with the institution leadership and beyond, to find possible solutions. Improvement of publication and dissemination strategies is recognised by the group as a challenge to be addressed and some recommendations concerning other aspects of the group's operations have been given in further sections of this evaluation document.

**Research group Subsurface Flow Laboratory (SFL) overall assessment**

SFL has the potential to support the use of the subsurface in the energy transition. However, the group's research direction is mainly dictated by the clients' needs. While adapting to the market is understandable, especially for a group mainly relying on industry-based projects for funding, the Expert Panel believes there would be a value in defining areas of excellence that the group would like to strengthen and promote. The Expert Panel concludes that SFL operates in a very strong supportive environment. However, it notes that the self-assessment does not consider the adequacy or completeness of the available equipment in perspective of new research areas related to the energy transition. The Expert Panel considers that an evaluation of the strengths and weaknesses of the current infrastructure should be undertaken and the potential need for further instruments considered. The Expert Panel considers that SFLs research outputs are of a quality sufficient to receive some international recognition and that the group has had a considerable role in the research process behind them. The Panel is finds that the economic impact is only modest and that societal partners only play a modest role. The Expert Panel notes that this performance is much weaker than expected for a group funded mainly by industry projects.

**Research group Energy Modelling and Automation overall assessment**

The research group is very strong in implementing and maintaining simulation infrastructure. Demonstrating the first autonomous drilling was an important achievement. The quality of the research papers, given this achievement, is disappointing. The self-assessment document notes that the high number of users of the EMA's simulation software is an indicator of research quality – The expert panel disagrees fundamentally with this approach and notes that the number of users is not a reliable indicator. EMA's level of contribution to the research papers the Expert Panel has reviewed is considerable. Its societal impact and

user involvement need to be quantified more carefully with evidence of the user base influencing the development of EMAs tools. More critically, EMA needs to develop international partnerships and engage in international projects to broaden the impact of its work and capitalise on its achievements to date.

**Research group Computational Geosciences and Modelling (CGM) overall assessment**

CGM is highly reputed at the national level, possibly because of a significant number of chief and senior researchers. However, it appears this comes at the cost of lacking a gender and age balance. Shifting from R toward subsurface hydrogen and CO2 storage along with maintaining the competence of petroleum has been successful as there is an obvious connection among the disciplines. The group had to also select another renewable, which was wind energy, but the rationale for this selection is not explained in the self-assessment report – it can be inferred that modelling capabilities can be applied to several fields. The group has many collaborations, but they are mainly at the national level whereas at the international level, collaborations largely come from reputation and expertise rather than being proactively sought. The support for students is strong. The Expert Panel infers that, likely, students are a means to compensate for the lack of young personnel. However, they also note that PhD students typically hold temporary positions, so they are not a long-term investment. The majority of funding is from RCN (80%), which appears to be decreasing in favour of funding from other national sources and also from private companies. However, the latter trend is not yet well-established as the monitoring period is only 4 years long. The Expert Panel notes that funding from the industry might not increase as expected because the industry typically supports the implementation of proprietary technology, which is incompatible with the development of open-source codes. The Expert Panel was surprised that funding from international projects (including EU programmes) is negligible. Enhanced international collaborations would strengthen the group's international network and increase successful participation in EU projects. The organisation needs to encourage such participation and promote CGM internationally. The Panel was also concerned that much of the user engagement is one-way and, consequently, recommends that an independent advisory board is used to assist in planning and fore sighting.

**Research group Data Assimilation and Optimization (DAO) overall assessment**

The group has strong competence in his research area DA and optimisation at an international standard. It is successful in applying this competence in various industrial sectors, but mainly in the petroleum sector. While this is a clear strength of the group, the challenge will be to map the core expertise relative to new evolving sectors, i.e. the offshore wind energy sector, and to adapt the size and structure of the group. Internationally there are very large industry focused research groups working to support Offshore Wind and DAO will need to engage with them. The administrative functions of NORCE do not seem to support the development, maintenance and promotion of open-source software. Consequently, the organisational structure is only modestly supporting the delivery of excellent research. The quality of the groups work in terms of its research publications and the contribution to them is sufficient to gain some international recognition. Greater impact will need participation in international projects and engagement with international partners. The DAO’s economic and societal impact, on the Norwegian economy, is on a level expected with a similarly sized group working in this area. The project driven nature of their funding leads to considerable engagement with partners in all parts of the research process.

**Research group Well Operations and Risk Management (WORM) overall assessment**

The Expert Panel notes that the group is clearly strong, in both a national and international context, in the field of P as evidenced by the hosting of two national research facilities, as well as the ability to attract both research council and industry funding. However, a key goal of WORM is to publish in high-level journals. This has not been achieved and may prove difficult due to both the applied nature of the research being conducted and the fact that much of the focus of the group seems to be on completing existing projects and attracting new projects to finance the group. Another key goal of the group is “to ensure activity and relevance within existing areas/domains, manage and develop our unique infrastructures, expand project volume with current clients and identify and transition our work into new domains“. WORM has, and should continue to, achieve these goals. However, the self-assessment report does not provide a clear vision regarding the direction in which infrastructure will develop in relations to the way that the use of the subsurface is likely to evolve. The self-assessment report provides clear evidence that the group is expanding the range of projects being conducted particular in the field of energy systems; although the Expert Panel notes that some of these projects seem outside of the remit of a research group named “well operations and risk management”. The Expert Panel notes that much of the current income of the research group is focused on a single project (P innovation program), which could make it vulnerable to changes in state and industry funding priorities. The key strengths of WORM include its expertise and infrastructure based around P and large-scale testing. Also, the group is attracting more projects related to NetZero including CCS and geothermal, which the Expert Panel commends. Its key weakness is that it does not publish its core research (i.e. well operations and risk management) in journals that are not directly related to the petroleum industry. The Expert Panel believes that the research conducted by WORM is making significant societal impact, but this is understated in the self-assessment report.

**Research group Digital Systems (DS) overall assessment**

The main strengths of the organisation rely on their past software developments, that they still develop and maintain, which are relevant in terms of societal impact. Among the main weakness are the lack of a good international projection, gender unbalance, the lack of a mobility programme, PhD students, the low number of publications and the low connection with the general public in terms of publications and dissemination activities. This evaluation reflects the discrete performance and contribution of the group in terms of research, in a national and international scope. The group has scored medium in most of the dimensions. Even with a good organisational environment, the positioning of the group internationally is not clear, lacking a high-quality research own production, even they still keep some successful software developments with a good societal impact. The group doesn’t show a relevant international impact, since most of their collaborations are with other Norwegian organisations. The number of European projects achieved after the group creation is not very relevant which makes the collaborations with other international research organisations weak.

## 3. Diversity and equality

The work on gender equality and diversity is centrally led and anchored within the NORCE Strategy 2022- 2025, based on the premise that a diverse and equal NORCE will contribute to a more democratic and sustainable society, and that the company will be better equipped to face the future through research and innovation that is able to reach a broader group of end users. The NORCE Action Plan for Gender Equality addresses specific initiatives, and the work is managed by a Committee for Equality and Diversity, supported by an HR

resource in a 10% position as well as other administrative resources as needed. The Committee audits the action plan as part of its mandate.

The statistics for recent years are summarised in Table 45 taken from the SSB report: Analysis of research personnel. The data shows that during the period from 2013 to 2021, the total number of researchers is reducing, and that the percentage of female researchers is also reducing. Overall, the trends are worrying, and the admin unit did not present very clear plans for turning them. This should therefore be addressed.

**Table 4.5 Personnel statistics for NORCE Technology, 2013, 2017 and 2021**

| Indicators | 2013 | 2017 | 2021 |
|---|---|---|---|
| Total researchers | 197 | 196 | 174 |
| Female researchers | 44 | 41 | 35 |
| Male researchers | 153 | 155 | 139 |
| Share of female researchers | 22 | 21 | 20 |
| Share of researchers with phd-degree | 55 | 64 | 78 |
| Share of female researchers with phd-degree | 55 | 68 | 71 |
| Share of male researchers with phd-degree | 55 | 63 | 80 |
| Share of researchers with foreign phd-degree | 15 | 14 | 19 |
| Average age, all researchers | 41 | 43 | 45 |
| Average age, female researchers | 38 | 41 | 43 |
| Average age, male researchers | 43 | 44 | 46 |
| Share of researchers 62 years or older | 5 | 7 | 6 |

Source: Statistics Norway

## 4. Relevance to institutional and sectorial purposes

The overarching strategy for NORCE has a vision "Passion for knowledge – together for sustainability" and the E&T Division follows the NORCE strategy for impact and institutional relevance. Four focus areas are identified for cross-disciplinary effort:

- Climate challenges;
- Sustainable sea and coast;
- Sustainable energy production;
- Safe communities.

All of these objectives clearly align with both national and international priorities.

NORCE aims to deliver research, innovation and solutions for key topics within policy-making and public administration, business, and civil society; thereby contributing to a green transformation of industry and society. Advice to governmental organisations is based on commissioned research, categorised mainly as applied research spanning TRL 4-7. To ensure policy and social impact, NORCE collaborates with different sectors of society: academia, research institutes, industry, clusters, agencies, municipalities and NGOs. This includes direct partnerships, inclusion in reference panels as well as targeted stakeholder interaction.

Research activities at E&T are performed in different types of projects and centres, with a range of ways for user involvement in terms of in-kind contribution and cash contribution:

- Centres and KSP projects: User involvement is in regular technical meetings where results are presented and discussed, board meetings where priorities are set and case studies in collaboration with users.
- IPN: The user will be the owner of results and responsible for commercialisation.

- Frame agreements: Dedicated projects are initiated efficiently and performed in close dialogue with the user according to user needs.
- Demonstration project: End users are involved in the definition of the project, following up the project at regular meetings and provide resources to facilitate demonstrations according to user needs.
- Joint Industry Projects: For projects fully financed by the industry, the user interest must be very high and strong user involvement in technical meetings.

Based the breadth of projects reported in the self-assessment report, the impact cases presented, and the consistency of the funding secured for contract research, it is clear to the evaluation committee that the admin unit has good relations and trust with several major customers and high resale share.

In line with its own objectives, the evaluation committee would like to highlight that some companies that the E&T Division work with are likely to be seeking to transition their own activities to the green agenda and NORCE E&T should take a leading role to support the shift in research rather than waiting to follow the industry. In this vein, the admin unit will need to make strategic choices around which areas within the green transition it would like to position itself in relation to its industry partners.

## 5. Relevance to society

The Norwegian Long-term plan for Research and Higher Education, societal challenges more widely, and the UN Sustainable Development Goal, LTP (2019-2028) presents three objectives: Enhancing competitiveness and innovation, tackling major societal challenges and to develop research communities of outstanding quality. The NORCE E&T Division is relevant for many of the objectives and long-term priorities given in the LTP, such as how to contribute to the green transition.

Norce E&T contributes directly to 1) Oceans and coastal areas, 2) Climate, the environment and energy 3) enabling and industrial technologies and 4) Societal security and civil preparedness. This is also reflected in the strategic priorities within the division and research groups. Research includes how to reduce climate effects of the O&G industry and sustainable use and management of the environment and natural resources, specifically, to generate knowledge and technological solutions necessary for the blue-green shift and contribute innovative solutions fuelling the circular economy.

Since 2020 NORCE has published its own sustainability report, and internally all project leaders are asked to consider how the projects promote the different sustainability goals. NORCE E&T division mainly works towards SDG: 3, 7, 9, 11, 12, 14, and 15 and ensures SDG 5 and 12 in its activities.

NORCE also engages with the wider society through science festivals, industry conferences, media outreach (articles in newspapers, interviews), and arranging open meetings.

### 5.1 Impact cases

**Comments to impact case 1:** Automated drilling

The service company Sekal was established in 2011 based on results from research and development at RF-Rogalandsforskning and IRIS. Novel products and services for drilling automation are made available to the industry. Sekal is the market leader within drilling automation and real-time drilling engineering, and 14 large international companies have used the technology. The technology has been used to optimise the drilling performance in

more than 900 wells around the world. Sekal has now 45 employees in Norway and an office in Aberdeen with 80-90 employees.

The research group Energy Modelling and Automation (previously Drilling and Well Modelling) at IRIS/NORCE have continued with independent research and development within drilling automation for knowledge building and innovation. A large part of the research has been, and still is, important for further development of the products DrillScene and DrillTronics. The research results have been openly and widely published at conferences and in journals. The research team has also been very active in international committees to promote interoperability standards to ease the deployment of drilling automation, donated open-source software and contributed largely to increased global knowledge about drilling automation.

- NORCE Chief scientist has been the leading scientist in the research group and in 2022 he received the global Drilling Engineering Award.
- The world's first autonomous full-scale autonomous drilling operation was demonstrated at Ullrigg, (https://doi.org/10.2118/210229-MS). A total of 500 m in length was drilled fully autonomously, and the decisions were made by the system itself using the AI method Markov decision process.
- Significant impact on industry processes for real time automated drilling processes for fixed and floating implementation.

Strong case underpinned by open research and with high impact on industry access (14 large international companies have used the technology) and on spin-out company with 45 employees in Norway and 80-90 in UK. Good research publications in open access, global awards, lacking quantified impact on business.

**Comments to impact case 2:** Technology development and commercialisation

Technology development and commercialisation are central to the activities of the energy and technology division. The impact of these activities are new products and processes, new companies and new workplaces. E&T Division develops its own IPR to facilitate research and commercialisation activities, spin off companies and licensing. In the period spin off companies such as XSENS, Offshore Sensing, and Indikel were launched. Impact case focuses on XESNS, now a company providing clampon ultrasonic measurement technologies. Starting in basic research ending in a sound company with a stable, growing workforce.

Developed a patented technology for use on a global scale by large operators for high accuracy flow and fraction measurement of different types of liquids, gases, and other media. The company has expanded its owner base with 3 seed-fund. Won «Offshore Technology Conference» Spotlight on new Technology - Small Business Award, Houston, USA in 2019 and «ADIPEC Oil and Gas start-up of the year», in Abu Dhabi in 2020. Their products are sold to several sites and customers, and they are expanding their portfolio. They have expanded their domain from Oil & Gas to process industry and water supply, with accompanying products and services. The company now has 16 (31.12.22) employees and are located at modern office and production premises in Godvik close to Bergen

Good impact, basic research leading to spin out company and new technology used on a global scale by large operators, winning awards in US and Abu Dhabi. Publications in academic journal (one only listed) and patents.

**Comments to impact case 3:** Visualisation and analytics software

An integral part of the work in several of the research groups are development of research based visualisation and analysis software solutions that make significant impact in their application areas. Exemplified here by three different solutions in different domains. Enlighten is a general interactive visualisation framework developed as an extension of the doctoral work of one of E&T divisions employees. NLive is a visualisation solution that enables high-performance visualisation of georeferenced and time-stamped datasets in 3D on a virtual globe, on the web or in virtual reality. LSSS (Large-scale survey system) is a solution for supporting abundance estimation of fish schools interpreting large scale acoustic data.

The impact case describes software solution developments, following on from PhDs and basic research. The software is commercialised in the sector, and research has been published in conference and journal publications in the public domain.

- NLive has been used extensively for NORCE's drone activities for monitoring and sharing flight data both internally and externally.
- Enlighten-web, impact has so far been mainly as a tool in research. The EPOS-N portal (https://epos-no.uib.no/eposn-data-portal/ ) is implemented based on Enlighten.
- LSSS was developed in close collaboration with the Institute of Marine Research and is deployed by several marine research institutes around the world.

Lacking data on number of users, which would strengthen the breadth of impact. Not clear whether the software is used by academic institutes only or by industry as well.

**Comments to impact case 4:** Synthetic Aperture Radar Interferometry (InSAR) for ground deformation

Automated SAR Interferometry (InSAR) based on the Sentinel-1 satellites combined with the NLIVE visualisation tool has been used to set up operational Ground Motion Services (GMS) in Norway (www.insar.ngu.no), Sweden (https://insar.rymdstyrelsen.se/), and Europe (https://egms.land.copernicus.eu/). The services led to the discovery of unknown landslides that can endanger population and infrastructure. Mapping and monitoring these hazardous landforms contribute to assessing the needs for further actions to mitigate the risk in mountainous regions. InSAR also documents urban subsidence and deformation of man-made structures that can lead to destabilisation or long-term damage. At NORCE, InSAR technology led to advanced research in geosciences to document the dynamics of periglacial landforms especially sensitive to the changing climate.

Building on the international recognition of the world-leading expertise of NORCE in large-scale InSAR processing, several follow-up public services were funded in the past years (InSAR Sweden: 2021-2022 ; the European Ground Motion Service: 2021 and onwards, first release in 2022). Since their release, the GMS have been used operationally by a wide range of users, from public administrations and private companies

Underpinned by PhDs, As a continuation of this work, several projects are now ongoing to further exploit InSAR-based products for operational assessment of changing permafrost conditions (infrastructure and geohazard management) and for climate change research (coupling with modelling, generation of new parameters of the Essential Climate Variable ECV Permafrost).

PhD theses listed as references; publications also listed. Impact appears to be mainly in research and ongoing projects. Evidence of further impact and breadth is not given, e.g.,

number of users and impact on business. Quantified data would be valuable to provide evidence of impact.

## Methods and limitations

### Methods

The evaluation is based on documentary evidence and online interviews with the representatives of Administrative Unit.

The documentary inputs to the evaluation were:

- Evaluation Protocol that guided the process
- Terms of Reference
- Administrative Unit's self-assessment report
- Administrative Unit's impact cases
- Administrative Unit's research groups evaluation reports
- Bibliometric data
- Personnel and funding data
- Data from Norwegian student and teacher surveys (only for HEI's)

After the documentary review, the Committee held a meeting and discussed an initial assessment against the assessment criteria and defined questions for the interview with the Administrative Unit. The Committee shared the interview questions with the Administrative Unit at least two weeks before the interview.

Following the documentary review, the Committee interviewed the Administrative Unit in an hour-long virtual meeting to fact-check the Committee's understanding and refine perceptions. The Administrative Unit presented answers to the Committee's questions and addressed other follow-up questions.

After the online interview, the Committee attended the final meeting to review the initial assessment in light of the interview and make any final adjustments.

A one-page summary of the Administrative Unit was developed based on the information from the self-assessment, the research group's evaluation reports, and the interview. The Administrative Unit had the opportunity to fact-check this summary. The Administrative Unit approved the summary with minor adjustments.

### Limitations

The Committee judged that the Administrative Unit self-assessment report was insufficient to assess all evaluation criteria fully. However, the interview with the Administrative Unit filled gaps in the Committee's understanding, and the information was sufficient to complete the evaluation.

## List of administrative unit's research groups

| Institution | Administrative Unit | Research Groups |
|---|---|---|
| NORCE | NORCE Energy and Technology (E&T) | Modelling and Simulation (ModSim)<br>Data, AI, Robotics, Vision, Visualization, Immersion (DARWIN)<br>Energy Modelling and Automation<br>Well Operations and Risk Management (WORM)<br>Coastal and Ocean Systems (COS)<br>Air and Space<br>Computational Geosciences and Modelling (CGM)<br>Subsurface Flow Laboratory (SFL)<br>Autonomous Systems and IoT (IoT)<br>Measurement Science<br>Data Assimilation and Optimization (DAO)<br>Digital Systems (DS) |

## Terms of Reference (ToR) for the administrative unit

The board of NORCE Norwegian Research Centre AS mandates the evaluation committee appointed by the Research Council of Norway (RCN) to assess the Technology Division in NORCE based on the following Terms of Reference.

**Assessment**

You are asked to assess the organisation, quality and diversity of research conducted by Technology Division as well as its relevance to institutional and sectoral purposes, and to society at large. You should do so by judging the unit's performance based on the following five assessment criteria (a. to e.). Be sure to take current international trends and developments in science and society into account in your analysis.

a) Strategy, resources and organisation

b) Research production, quality and integrity

c) Diversity and equality

d) Relevance to institutional and sectoral purposes

e) Relevance to society

For a description of these criteria, see Chapter 2 of the mathematics, ICT and technology evaluation protocol. Please provide a written assessment for each of the five criteria. Please also provide recommendations for improvement. We ask you to pay special attention to the following 8 aspects in your assessment:

1. The Technology division has several strategic initiatives. Have we chosen the right ones, and do we have sufficient/right resources to win the competition for the major projects/centres nationally/internationally? Are we appropriately organised to support our strategic initiatives?
2. The Technology division is hosting/participating in several centres. To what extent do we take advantage of this position?
3. A large proportion of the groups in the division have long experience with research projects related to the petroleum industry and are internationally recognized in their fields. The strategy is to "Be a visible and leading national and international player in energy research by further developing expertise, capacity and infrastructure within environment-friendly energy and consolidating our strong position within petroleum (contributing to improved recovery with reduced emissions)". To what extent have we succeeded in shifting to renewable and sustainable energy research?
4. NORCE Technology have international leading research in several fields, to what extent do we succeed in utilize this advantage?
5. NORCE has a wide range of expertise in the three divisions: Health and Social science, Climate and Environment, and Technology. This gives us the potential to create inter- and multidisciplinary projects that address major societal challenges. To what extent have we succeeded in this?
6. Our infrastructure is extensive. Does the infrastructure support our research activities and enhance our competitiveness?
7. How can we exploit the possibilities for EU funding in a better way?
8. Does our research impact the wider society and businesses, including innovations and commercialization of results?

In addition, we would like your report to provide a qualitative assessment of Technology Division as a whole in relation to its strategic targets. The committee assesses the strategy that the administrative unit intends to pursue in the years ahead and the extent to which it will be capable of meeting its targets for research and society during this period based on available resources and competence. The committee is also invited to make recommendations concerning these two subjects.

### Documentation

The necessary documentation will be made available by the mathematics, ICT and technology secretariat at Technopolis Group.

The documents will include the following:

- a report on research personnel and publications within mathematics, ICT and technology commissioned by RCN
- a self-assessment based on a template provided by the mathematics, ICT and technology secretariat
- relevant strategy documents
- organisational charts
- relevant statistics and analytics

### Interviews with representatives from the evaluated units

Interviews with the Technology Division will be organised by the evaluation secretariat. Such interviews can be organised as a site visit, in another specified location in Norway or as a video conference.

### Statement on impartiality and confidence

The assessment should be carried out in accordance with the Regulations on Impartiality and Confidence in the Research Council of Norway. A statement on the impartiality of the committee members has been recorded by the RCN as a part of the appointment process. The impartiality and confidence of committee and panel members should be confirmed when evaluation data from Technology Division are made available to the committee and the panels, and before any assessments are made based on these data. The RCN should be notified if questions concerning impartiality and confidence are raised by committee members during the evaluation process.

### Assessment report

We ask you to report your findings in an assessment report drawn up in accordance with a format specified by the mathematics, ICT and technology secretariat. The committee may suggest adjustments to this format at its first meeting. A draft report should be sent to the Technology Division and RCT]. The Technology Division should be allowed to check the report for factual inaccuracies; if such inaccuracies are found, they should be reported to the mathematics, ICT and technology secretariat within the deadline given by the secretariat. After the committee has made the amendments judged necessary, a corrected version of the assessment report should be sent to the board of NORCE Norwegian Research Centre AS and the RCN no later than two weeks after all feedback on inaccuracies has been received from Technology Division.

# Appendices

1. Description of the evaluation of EVALMIT
2. Invitation letter to the administrative unit including address list
3. Evaluation protocol
4. Template of self-assessment for administrative unit (short-version)

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